1973/136
Copy 3

Restricted until after publication.
Manuscript submitted for publication
to: DSDP Leg 27

CANCELLED

DEPARTMENT OF MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1973/136

GEOCHEMISTRY AND DIAGENESIS OF INTERSTITIAL FLUIDS AND ASSOCIATED CALCAREOUS OOZES, DEEP SEA DRILLING PROJECT, LEG 27 SITE 262, TIMOR TROUGH

by

P.J. Cook

1973/136

GEOCHEMISTRY AND DIAGENESIS OF INTERSTITIAL FLUIDS AND ASSOCIATED CALCAREOUS OOZES, DEEP SEA DRILLING PROJECT, LEG 27 SITE 262, TIMOR TROUGH

by

Peter J. Cook [1]

Bureau of Mineral Resources, Canberra, A.C.T., Australia

---

[1] Published with the permission of the Director, Bureau of Mineral Resources, Geology and Geophysics, Canberra.

ABSTRACT

Detailed geochemical work was undertaken on pore water and sediment samples from a drill hole (D.S.D.P. Hole 262) sited on the axis of the Timor Trough. The sediments comprise calcareous ooze with variable quantities of clay minerals. High magnesian calcite is absent, though aragonite is present throughout the sequence. Dolomite rhombs are common, particularly in the lower half of the hole, where they are believed to have formed diagenetically by the action of saline pore fluids on the calcareous ooze. Factors influencing the chemistry of the pore waters include:

1. The increasing carbonate content of the sediments with increasing depth; this has a relatively minor effect on the chemistry of the pore water.

2. The presence of large amounts of plant material in the sediments and the associated bacterial fermentation and sulfate-reduction. This produces a solution rich in HCO^{-}_{3} (and an abnormally high alkalinity) and a depletion of SO_4^{--}. There is also a decrease in the Ca^{++} concentration but the reasons for this are less apparent.

3. The influx of highly saline waters in the lower half of the hole. These are believed to emanate from evaporite deposits.

INTRODUCTION

Continuous coring of pelagic calcareous sediments at D.S.D.P. site 262 in the Timor Trough (Fig. 1) at a water depth of 2315m provided abundant core material for geochemical work, including onboard extraction of interstitial water. A 6-cm length of material was taken from each core, giving a vertical sampling interval of approximately 10m, compared to the normal sampling interval of approximately 50 m. As comparatively large amounts of sediment and water were available it was also possible to undertake a wide range of analyses on the 45 samples obtained.

The drill hole intercepted a total of 442 m of grey calcareous sediments. The sequence was composed of 414 m of Quaternary and upper Pliocene planktonic ooze overlying 13 m of upper Pliocene shallow marine foraminiferal dolomitic mud and 15 m of upper Pliocene very shallow marine dolomitic shell calcarenite. Thus the sequence becomes progressively of shallower origin with increasing depth down the hole. It is also evident that for the past 4-5 million years a comparatively rapid rate of deep-sea sedimentation (about 1 cm per 100 years) has prevailed in the Timor Trough.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge the valuable contributions made to this portion of the Leg 27 program by Mr J. Pine of the Deep Sea Drilling Project who carried out the on-board extractions and determinations, and the staff of the Analytical Chemistry Section of the Australian Mineral Development Laboratories who were responsible for most of the onshore geochemical analyses. The assistance of Messrs W. Mayo, G. Berryman, and K.J. Armstrong of the Bureau of Mineral Resources is also greatly appreciated.

ANALYTICAL PROCEDURES

After on-board extraction using a modified hydraulic press, the interstitial water was stored in sealed plastic tubes of about 10-20 ml volume. A small quantity of water was used for on-board analysis, including the determination of pH by the 'flow-through' and 'punch-in' methods, alkalinity by potentiometric titration, and salinity by the refractive index method using a Goldberg optical refractometer. All the on-board analyses and the methods used are standard for each leg of the Deep Sea Drilling Project.

The squeezed sediments were heat-sealed in plastic bags, and, before analysis, were dried and ground to approximately 100 mesh. Chemical analyses on the water and sediment were subsequently undertaken at the Australian Mineral Development Laboratories, Adelaide; mineralogical analyses were carried out at the Bureau of Mineral Resources, Canberra.

Onshore water analyses

Immediately upon opening the vials the samples were acidified with a known volume of 10 percent hydrochloric acid. Analyses were then undertaken as follows:

Ca, Mg, Sr, and Ba were determined by atomic absorption spectrometry using a nitrous oxide flame, a dilution ranging from 10-fold to 50-fold, and, where appropriate, an acid solution of KCl to suppress ionization. Fe, Mn, and Zn were determined directly by air-acetylene flame atomic absorption spectrometry using x20 and x30 scale expansions, and reading on a chart recorder; background corrections were made using a hydrogen lamp. Cu was determined by air-acetylene flame atomic absorption spectrometry after extraction, using methyl isobutyl ketone as the solvent and ammonium pyrrolidine thiocarbamate as the chelating agent (St John, 1970). P_2O_5 was determined colorimetrically after neutralizing with NaOH solution.

Absorbance was read at 880 nm in 2-cm cells against standards prepared in a similar matrix of NaCl. This method is fully described by Murphy & Riley (1962). Chloride was determined by titration against silver sulfate using an electrometric end-point. sulfate could not be determined by the classical precipitation method because of the small amount of material available and it was obtained by determining the amount of Ba (by atomic absorption spectrometry) precipitated from solution as $BaSO_4$.

Onshore sediment analyses

Mineralogical analyses were undertaken on a conventional Phillips X-ray diffraction unit at standard settings. Preferred orientation effects were minimized by the use of a spinner. Calcined fluorite was used as an internal standard. Peak areas were determined using an electrically triggered planimeter. Peak positions were also measured and the Goldsmith & Graf (1958) relation used for the determination of carbonate mineralogy.

Various techniques were used for the chemical analyses. P_2O_5 was determined spectrophotometrically using the molybdenum blue method. CO_2 was determined gravimetrically. All other elements were determined by atomic absorption spectroscopy on total solutions of the samples using mixed acids and HF.

In order to check the mineralogical significance of geochemical results a number of samples were impregnated and thin sections cut.

RESULTS

The results of pore water and sediment analysis of the 45 samples from throughout D.S.D.P. Hole 262 are given in Table 1. Tests of precision were undertaken on both pore water and sediment samples where sufficient material was available. In general, standards of reproducibility for pore water analyses were acceptable, including those for Mg (± 2.4%), Ca (± 2.2%), K (± 1.7%), Sr (± 2.6%), Li (± 3.5%), Cl^- (± 0.5%), and SO_4^{--} (± 1.0%). Less satisfactory levels of precision were obtained for P_2O_5 (± 34.0%), Fe (± 23.2%), Mn (± 19.1%), and Zn (± 26.7%).

Precision levels were generally good for the sediment analyses, including those for Ca (± 0.6%), Mg (± 1.9%), Sr (± 1.3%), Li (0%), Fe (± 1.5%), CO_2 (± 1.7%), Cu (± 2.8%), Mn (± 1.9%), and P_2O_5 (± 3.8%). Acceptable levels were obtained for K (± 7.0%), Ba (± 8.7%), Zn (± 6.6%), and Cr (± 8.8%). Poor levels of precision were obtained for Pb (± 30%), Co (± 11.9%), and Ni (± 25.9%).

The degree of accuracy is more difficult to establish, and is rather less important to a relative study of this type than the precision. Comparison of the Timor Sea surface water analyses with those of standard sea water suggests that a reasonable level of accuracy was obtained.

Mean compositions for the upper and lower halves of Hole 262 are given in Tables 2 and 3. In addition, the vertical variation in major and trace element compositions of the pore water and the sediment are shown in Figures 2 and 3.

DISCUSSION

PORE WATERS

Mean pore water compositions for Hole 262 are given in Table 2. Many of the values do not appear to differ significantly from values obtained from Leg 8 (Presley & Kaplan, 1971; Manheim & Sayles, 1971). However, there are some notable differences including salinity, alkalinity, chlorinity, Ba, and Fe which are considerably greater, and SO_4, Ca, and Mn which are significantly less in Hole 262 than in Pacific sediments obtained on Leg 8. It seems probable that the pore waters in Hole 262 show marked enrichment in total dissolved salts, P_2O_5, K, Ba, Fe, Mn, Zn, and HCO_3^- (as indicated by the alkalinity value) and significant depletion in SO_4 and Ca when compared with Timor Sea surface water.

Equally marked differences between the elemental composition of pore waters in the upper part of the hole and those in the lower part are also apparent from Table 2. It is clear from Figure 2 that these vertical changes are in general gradational, and that many of them are inter-related, with for instance Sr varying sympathetically with Ca. Some of these inter-relations will be discussed in some detail.

Using a computer program written by Mayo (B.M.R., *pers. comm.*), X-Y plots, the equation of the regression line, and correlation coefficients were obtained for all inter-element associations. These inter-relations are summarized in the form of a correlation matrix (Table 4), and it is clear from this that there are a number of associations. At the 99% confidence level the following components show a positive correlation with depth: Salinity, Cl^-, SO_4, Cu, Ca, Sr, and Li; a negative correlation is shown by alkalinity, P_2O_5, Mg, and K. Not surprisingly, most elements show a positive correlation with salinity, but Mg, K, and Ba are notable for their negative correlation.

Many components show strong positive correlations with alkalinity, including P_2O_5, Mg, and K, but Cl, Ca, Sr, and Li all show a strong negative correlation. pH is notable for its paucity of significant correlations; only Mn and K show a correlation with pH at the 99% confidence level. Some of the more important components will now be considered in some detail.

Anions Cl^-, SO_4^{--} HCO_3^- (alkalinity) and PO_4^{---} (P_2O_5)

These four anions make up the dominant anionic components in ocean waters and pore waters of essentially oceanic origin. However, in pore waters from D.S.D.P. Hole 262, the relative proportions as well as the absolute amounts deviate markedly from those in sea water and most other pore waters in deep ocean sediments.

Chlorinity and salinity gradually increase down the hole attaining a maximum of 33.1% Cl, equivalent to a salinity increase of about 50% above normal sea water. In previous D.S.D.P. drilling, salinities of this order have been encountered only in areas underlain by evaporites, such as the Red Sea (Leg 24). It therefore seems reasonable to postulate that the high Timor Trough salinities possibly result from the influx of brines, emanating from evaporite deposits which may underlie the Timor Trough. There is no direct evidence of such evaporites although the shallow-water aspects of sediments at the bottom of the hole suggests that deposits are cetainly possible.

The sulfate content of the pore waters also increases down the hole and there is a 99% probability that SO_4^{--} correlates positively with Cl^-, which is the normal relationship. Despite the high salinities, the SO_4^{--} content of the waters is, however, abnormally low (Table 2) compared with sea water and most other pore waters, implying that SO_4^{--} is being extracted from the system. This will occur readily at high salinities (greater than about 39^{o}/oo total dissolved salts) when gypsum will precipitate out.

<u>equation 1</u>. $Ca^{++} + SO_4^{++} \rightleftharpoons Ca\ SO_4$

The positive correlation between Ca and SO_4 at a greater than 99% confidence level supports the validity of this reaction. However, the situation is rather more complex as SO_4^{--} is apparently being withdrawn from the system in the upper half of the hole at salinities which would normally be insufficient to look for an alternative mechanism. Sulfate-reducing bacteria may be present in the sediments producing reactions such as:-

equation 2. $SO_4^{--} + 2C \rightleftharpoons S^{--} + 2\,CO_2$

equation 3. $SO_4^{--} + CH_4 \rightleftharpoons HS^{-} + HCO_3^{-} + H_2O$

Both equations only approximate the natural reactions because of the highly complex nature of the organic material (see Berner, 1971, pp. 114-137), but are useful as simplistic models of the true systems. The abundance of pyrite in the sediments, the high alkalinity values, and the large quantities of CO_2 and CH_4 encountered during drilling all lend support to the importance of equations 2 and 3.

Alternative equations for the decomposition of carbohydrates and protein in the anaerobic calcareous sediments in the presence of sulfate-reducing bacteria are given by Berner (1966).

equation 4. $2CH_2O + SO_4^{--} + CaCO_3 \rightleftharpoons Ca^{++} + HS^{-} + 3HCO_3^{-}$

equation 5. $4CH_2NH_2COOH + 4H_2O + 3SO_4^{--} + Ca^{++} \rightleftharpoons 3HS^{-} + 9HCO_3^{-} + 4NH_4^{+}$

In the lower half of the hole, below a depth of about 280m, salinities may become sufficiently high for the reaction represented by equation 1 to become of minor importance. Above this depth, sulfate reduction is probably the dominant mechanism for the extraction of sulfate.

It is evident from equations 2 - 5 that in a closed system an increase in the activity of sulfate-reducing bacteria will lead to a decrease in the amount of SO_4^{--} and a consequent increase in the amount of HCO_3^{-} in solution. This should result in a negative correlation between sulfate and alkalinity and this is indeed the case at the 98 percent confidence level (Table 4).

Alkalinity results primarily from the generation of CO_2 which then goes into solution. At the pH levels encountered in Hole 262, bicarbonate is the dominant ion (Garrells & Christ, 1965; Krauskopf, 1967) and the reaction may be represented by:-

equation 6. $H_2O + CO_2 \rightleftharpoons H^+ + HCO_3^-$

Maximum alkalinity of 93 meq/l occurs at a depth of 50 m below the sediment-water interface. This is considerably in excess of any alkalinity previously recorded from the Deep Sea Drilling Project. A high rate of sedimentation (about 1 cm per 100 years) in the Timor Trough is probably instrumental in ensuring that abundant organic material is buried before any extensive oxidation takes place. Alkalinity may reasonably be taken as an indicator of biological activity in general and sulfate reduction in particular (Presley & Kaplan, 1968; Berner, Scott, & Thomlinson, 1970). The abundance of organic material and pyrite suggests that conditions are strongly anaerobic within the sediment. Consequently oxygenation of organic carbon is unlikely to be an important mechanism. Berner (1971) points out that microbiological fermentation reactions can produce CO_2 in an anaerobic environment, using the oxygen present in the organic matter. A simplified version of the reaction involving carbohydrate is:-

equation 7. $C_6 H_{12} O_6 \rightleftharpoons 3CO_2 + 3CH_4$

It is impossible to evaluate the relative importance of the biologically induced processes of fermentation and sulfate reduction in the determination of alkalinity. However, if alkalinity is an indicator of biological activity it is puzzling that the maximum value occurs at a depth of 50 m and not just below the sediment-water interface. The probable explanation for this is that the peak at 50 m is indicative of an ancient peak in biological activity rather than a modern. This would require that we are dealing here with a closed system. Alternatively biological activity might conceivably extend much farther below the sediment-water interface than is generally acknowledged.

The relation between alkalinity and pH is of some interest, for Gardner (1973) has postulated a theoretical pH-alkalinity relation in calcareous sediments which involves an asymtotic association, with the correlation curve lying parallel to the alkalinity axis at a pH of about 6.6 (Fig. 4). In the Timor Trough system, the asymptote in fact lies at a pH of 7.4 and 7.8 (Fig. 4). This is similar to the Florida Bay results of Berner (1966) who places the limit at 7.3 to 7.7. It is probable that the development of NH^+ and other ions which are not generally considered in theoretical systems are responsible for much of the deviation noted between the theoretical and the natural system.

Although P_2O_5 (primarily in the form of PO_4^{---}) makes a contribution to alkalinity, Gieskes & Rogers (1973) have shown that this contribution is negligible in most natural systems. Despite this, there is a strong positive correlation between alkalinity and P_2O_5 (Table 4). P_2O_5 also shows a significant positive correlation with Mg and K. This is perhaps a secondary correlation owing to the Mg and K content being dependant on alkalinity rather than from any tendency for these components to be PO_4^{---} dependant, though why Mg and K should be alkalinity-dependant is not clear. A possible explanation for the P_2O_5-alkalinity correlation is that the nutrient role of the phosphate radical is of some importance, so that abundant nutrients produce an increase in biological activity which in turn results in a high alkalinity value. Alternatively, alkalinity may itself have a direct influence on phosphate solubility.

Ca, Mg, K, Sr, Ba, Li

These alkaline earth metals are commonly associated in aqueous systems, but in the Hole 262 pore waters inter-relations appear to be fairly complex. All these captions will show a straight-line correlation with salinity if precipitation of components does not take place. Thus, Ca, Sr, and Li all show a strongly positive correlation with salinity (see Figures 5A and 5B). Mg, K, and Ba, on the other hand, all show a negative correlation with salinity (Fig. 5C). The complex nature of the relations is demonstrated by the Mg-salinity plot (Fig. 5D). The regression line indicates a negative correlation, but this oversimplifies the true picture as there are two distinct trends. At low salinities, Mg varies from 800 to 1600 ppm without any sympathetic change in salinity. This near-horizontal trend is confined to the upper half of Hole 262. The second trend is a strongly positive correlation between salinity and Mg content. Samples lying on this positive correlation line are all located in the lower half of the hole. The implication of these two divergent trends is that there are two sources of pore water, the first being oceanic water which has been incorporated and subsequently modified <u>in situ</u> in the interstices of the calcareous ooze in the upper half of the hole, and the second, found in the lower half of the hole, being derived from, or at least modified by, the influx of saline brines possibly emanating from inferred underlying evaporite deposits.

This two-fold source of interstitial fluids is also reflected in the Mg-Ca plot (Fig. 6), with totally different regression lines in the upper and lower halves of the drill hole. The regression line in the lower half of the hole conforms to the more normal Mg-Ca positive correlation, whereas the negative trend in the upper half of the hole suggests either that Ca is being removed or Mg is being added to the system. Figure 7A shows that there is no marked change in salinity in the upper half of Hole 262 associated with the change in the Mg/Ca ratio. Table 1 confirms that the high Mg/Ca values result primarily from low Ca concentrations. The correlation matrix (Table 4) indicates that the abundance of Mg in solution may be controlled in part by the alkalinity of the solution. Figure 6A shows the good positive correlation (confidence level greater than 99%) that exists between alkalinity and Mg. The Ca-alkalinity plots (Fig. 6B) shows a very different form, with the correlation line approximating an asymtotic curve.

The deficiency of Ca in the interstitial waters of the Timor Trough calcareous sediments is perhaps somewhat surprising. However, Berner (1966) found a similar feature in calcareous Florida sediments. He concluded that excess dissolved HCO_3^- was the prime cause of the deficiency, but suggested that Ca may also be extracted by the precipitation of calcium phosphate. The alternative explanation does not appear to be tenable for the Timor Trough sediments as there is no sympathetic depletion of phosphate in solution. Gardner (1973) offers the further alternative that in the presence of Fe_2O_3, sulfate reduction causes the precipitation of $CaCO_3$ and a consequent loss of Ca^{++} from solution. Although the Fe_2O_3 content of the Hole 262 sediments was not determined, comparison of the total Fe content (Table 1) with the pyrite content as determined by X-ray diffraction (H.E. Cook, this volume) suggests that Fe_2O_3 is probably abundant.

Sr and Ca are closely associated and show a strong positive correlation (Fig. 6D). However, there are evidently other factors controlling Sr solubility in addition to Ca, for the Ca/Sr ratio in normal sea water is approximately 56, whereas in Hole 262 Ca/Sr ranges from 5 to 20. This indicates that despite the marked absolute decrease in the amount of Sr in these pore waters compared with the abundance of Sr in normal oceanic waters, there is an enrichment when compared with Ca abundance. Figure 7B suggests that the Ca/Sr ratio may be partly controlled by Mg; as the concentration of Mg increase so the relative abundance of Sr decreases compared to Ca. The reason for this apparent association is not known.

Cu, Fe, Mn, Zn.

All the transition group elements tend to behave in a similar fashion, in that they show a marked increase in concentration in the pore waters compared to the concentrations encountered in surface sea water (Table 2). However, there are few clear correlations between these transition elements or with most of the other pore-water components. This is evident from the low correlation coefficients in Table 4.

Fe and Zn vary sympathetically but show no other significant correlations. Copper on the other hand does show significant positive correlations with depth, salinity and, chlorinity and negative correlations with alkalinity, P_2O_5, and Mg. Mn correlates negatively with pH. Overall however, Cu, Fe, Mn, and Zn show few definite patterns in these pore waters and no definite conclusions can be reached regarding the mechanism controlling their concentration.

SEDIMENTS

Mineralogy

X-ray diffraction analysis by the writer and by H.E. Cook (this volume) indicate that the sediments of Hole 262 are composed predominantly of calcite and clay minerals, with various amounts of aragonite, dolomite, quartz, and feldspar, and traces of pyrite and zeolites. There is a marked increase in the proportion of calcareous components with depth. There are also marked mineralogical changes in the calcareous fraction, with the proportion of dolomite increasing with depth. The proportion of aragonite in the carbonate fraction remains fairly constant throughout.

Using the method of Goldsmith & Graf (1958), it is possible to determine the amount of Mg substituting Ca in the calcite lattice. There is a slight increase in the amount of substitution of Mg in the lattice with increasing depth, but throughout the calcite is of the low-magnesian variety ranging from $Ca_{1.00}\,Mg_{0.00}\,CO_3$ to $Ca_{0.97}\,Mg_{0.03}\,CO_3$. The dolomite-type remains fairly constant and is an Mg - deficient form, ranging from $Ca_{0.60}\,Mg_{0.40}\,CO_3$ to $Ca_{0.54}\,Mg_{0.46}\,CO_3$. There does not appear to be any regular variation in the dolomite composition. The complete lack of any high-Mg calcite, even in the upper part of the hole where there is negligible dolomite, is somewhat surprising in view of the fact that the calcite is of biogenic origin. It is possible that the metastable high-magnesian calcite has reverted to low-magnesian calcite and dolomite. If this has in fact taken place, then the lack of a significant decrease in the abundance of metastable aragonite is rather puzzling.

Chemistry

The major and trace element composition of the 262 calcareous oozes is summarized in Table 1. It is apparent from this that there are some marked differences in the elemental composition of sediments in the upper half of the hole and those in the lower half, for example the Ca composition of the total sediment in the upper half of the hole averages 12.6 percent compared with 25.0 percent in the lower half. On the other hand, the Mg content of the total sediment only shows a small variation (1.23 to 1.54 percent) despite an increase in the dolomite component of the calcareous fraction from 2.0 to 14.5 percent. The vertical variations in both elemental and mineralogical compositions are summarized in Figure 3.

Despite these vertical changes, the average inorganic composition of the 262 oozes is very similar to the average composition of Leg 27 Cenozoic calcareous oozes (Table 3), and there is in turn nothing to indicate that these differ from normal oceanic calcareous oozes. Consequently, none of the unusual features of the pore-water composition can be explained on the basis of inorganic sediment composition. The fundamental abnormal feature is believed to be the abundance of organic plant material which has been incorporated in the sediment as a result of the close proximity of the Timor Trough to land, and the extremely rapid rate of sedimentation. The organic carbon is available as a biological nutrient. This ultimately results in the high alkalinities encountered in the sediments and is also responsible for the abundant pyrite; it may also play a role in the modification of carbonate mineralogy.

Non-calcareous components

Elements thought to fall into this category include Al, Fe, Co, Ni, Cr, Pb, Cu, Mn, Zn, Li, and Ba. All appear to be interrelated and commonly show positive correlations with each other (and negative correlations with the calcareous components - see Table 5). Some elements (such as Al and Fe) are essential lattice components of the clay minerals, whereas others such as Cu and Zn may be adsorbed on the clay particle surface. Some elements such as Mn may be present as finely divided metallic oxides or complex oxides or hydroxides. There is a marked difference in the Co, Ni, Mn, and Cr content of the calcareous oozes of Hole 262 and those of the other Leg 27 holes. Mn averages 544 ppm, whereas the other Cenozoic oozes of Leg 27 average 2600 ppm. The low values in 262 may be a reflection of the comparatively shallow water depth i.e. abyssal zone waters may be richer in Mn. Alternatively it may be a product of the high rate of sedimentation in the Timor Trough which results in the dilution of any chemical sediments.

Revelle (1944) first suggested that Ba is associated with carbonate in deep-sea sediments. Goldberg & Arrhenius (1958) subsequently suggested that the Ba content of deep-sea sediments is a function of the organic production of the euphotic zone, which is in turn partly dependant on latitude. Brongersma - Sanders (1967) showed that Ba becomes concentrated to a considerable degree in some diatom skeletons. In the Timor Trough sediments of Hole 262 Ba correlates positively (at the 99% confidence level) with Al_2O_3, Fe, and all the other non-calcareous components (see Table 5) and shows a negative correlation with the calcareous components. There is therefore no evidence from these analyses that Ba content is related to Ca CO_3. It could conceivably be related to the abundance of siliceous organisms but its strongest associations appear to be with terrigenous components such as clay minerals (as indicated by the

Ba-Al_2O_3 association) or with (?) inorganically precipitated oxides such as MnO (as indicated by the Ba-Mn association).

Calcareous components

Elements thought to fall into this category include Ca, Mg, C (expressed as CO_2), Sr, and P (as P_2O_5). All show good positive correlations with each other and negative correlations with the non-calcareous group of elements (Al_2O_3, etc. - see Table 5). Calcareous components show a marked increase in abundance with increasing depth. The positive correlation between P_2O_5 and Ca suggests that much of the P_2O_5 may be of biogenic origin and is incorporated in the skeletons of microfossils.

Sr values in general are fairly normal, except analysis 2 (Table 1) which appears to be anomalously high. A strongly positive correlation is evident between Sr and Ca, but there is a weakly negative trend between Sr and Mg. This may be a reflection of the loss of Sr as a result of the dolomitization of calcite i.e. replacement of Ca by Mg. There are marked variations in the Ca/Mg ratio which might reasonably be expected to correlate with the abundance of dolomite if the dolomite has in fact formed by the dolomitization of calcite, but such a trend is not clearly defined (Fig 8). This may be in part due to the fact that a significant amount of the Mg present in the sediments is associated not with dolomite (or magnesian calcite) but with the clay minerals. Additional possible mechanisms include direct precipitation of dolomite from solution rather than forming by the diagenetic dolomitization of calcite. Alternatively some of the dolomite may be allochthonous, derived from an older formation which is presently being eroded, but the Mg-deficient nature of the dolomite suggests that the dolomite is comparatively young.

If the trends of calcareous components in the sediments are compared with the trends of these same elements in the pore waters, correlations are in general either completely lacking or at best poorly defined. This is probably the result of most of the cations and anions in solution being derived from the original sea water rather than from the adjacent sediments.

However, there is a well defined positive correlation between the concentration of Mg in the pore water and the abundance of dolomite in the sediments. The Mg/Ca ratio does not appear to have any great importance to the dolomitization process in this particular environment. This is unlike the supratidal environment where the Mg/Ca ratio is of some importance (Muller et al., 1972, Cook, 1973).

Ca concentration in the interstitial waters shows a poorly defined positive trend with Ca concentration in the sediments, but alkalinity appears to have a much greater influence. Sr and P_2O_5 in solution show no obvious correlation with the Sr and P_2O_5 content of the sediments. The transition metals in pore waters and sediment also fail to show any sympathetic trends.

SUMMARY AND CONCLUSIONS

The sediments of Hole 262 are similar in composition to most other deep-sea calcareous oozes. The only exception to this is that Mn, Ni, Co, and Cr are somewhat impoverished. This may result from the comparative shallowness of the 262 oozes or alternatively is a consequence of the rapid rate of terrigenous and biogenic sedimentation which dilutes chemical sedimentation. The dominant trend in the sediments is one of increasing abundance of carbonate with increasing depth. This has a marked effect on the major and trace element geochemistry of the sediments, yet has little influence on the geochemistry of the pore-fluids. By contrast, the organic matter content of the sediments is believed to have a very marked effect on the chemistry of the pore waters. The organic matter present in the sediments is used by bacteria in sulfate-reduction and fermentation reactions and the nett effect of this is to produce abnormally high alkalinities in the pore waters. A sympathetic association between alkalinity and the Mg, K, and P_2O_5 content of the pore waters is apparent, but the reason for these interrelations is not understood. Other associated effects include the loss of SO_4^{--} from solution (by sulfate reduction), and also a decrease in Ca^{++} which may be related to the presence of Fe_2O_3 in the sediments (Gardner, 1973). The bacterial processes also results in the formation of pyrite in the sediments.

A further geochemical trend of some importance is that of increasing salinity with increasing depth. This has a marked effect on both the anionic and cationic composition of the pore waters. It is also believed to have some effect on the sediment composition and particularly the abundance of dolomite, as dolomite also shows a marked increase in abundance with increasing depth. There is also a poorly defined trend of increasing substitution of Mg in the calcite lattice with increasing depth but the complete absence of high-magnesian calcite is a puzzling feature, particularly as metastable aragonite is present throughout the hole.

In conclusion, there are three basic geochemical trends with increasing depth in D.S.D.P. Hole 262. These may be generalized as (1) decreasing alkalinity, which is primarily a reflection of decreasing bacterial activity with depth; (2) increasing salinity; and (3) increasing abundance of carbonates in the sediment.

A summary of the three trends is shown in Figure 9. Elements which are dependant primarily on one of these factors such as P_2O_5 and alkalinity (or bacterial activity) has a trend parallel to that factor. An element which is dependant on more than one factor, such as Mg, has a considerably more complex distribution pattern. Bacterial activity is thought to have a particular marked effect on the pore water composition in the upper half of the hole, whereas the effects of hypersalinity are dominant in the lower half. Both these features have a significant affect on the diagenetic changes taking place in the sediments.

REFERENCES

BERNER, R.A., 1966 - Chemical diagenesis of some modern carbonate sediments. *Amer. J. Sci*, 264, 1-36.

BERNER, R.A., 1971 - PRINCIPLES OF CHEMICAL SEDIMENTOLOGY. *McGraw Hill*, *New York*, 240p.

BERNER, R.A., SCOTT, M.A., and THOMLINSON, C., 1970 - Carbonate alkalinity in the porewaters of anoxic marine sediments. *Limnol*, *Oceanogr*. 15, 544-549.

BRONGERSMA-SANDERS, M., 1967 - Barium in pelagic sediments and in diatoms. *Proc. Koninkl. Nederland Akad. Wetensch*., 70(1), 93-99.

COOK, P.J., 1973 - The supratidal environment and geochemistry of some recent dolomite concretions, Broad Sound, Queensland. *J. sediment Petrol*., 43(4).

GARDNER, L.R., 1973 - Chemical models for sulfate reduction in closed anaerobic marine environments. *Geochim. cosmochim. Acta*, 37, 53-68.

GARRELLS R.M., & CHRIST, C.L., 1965 - SOLUTIONS, MINERALS, AND EQUILIBRIA. *Harper*, *New York*, 450p.

GIESKES, J.M., & ROGERS, W.C., 1973 - Alkalinity determinations in interstitial waters of marine sediments. *J. sediment Petrol*., 43 (1), 272-277.

GOLDBERG, E.D., & ARRHENIUS, G., 1958 - Chemistry of Pacific pelagic sediments. *Geochim cosmochim. Acta*., 13, 153-212.

GOLDSMITH, J.R. & GRAF, D.L., 1958 - Relation between lattice constants and composition of the Ca-Mg carbonates. *Amer. Mineral*., 43, 84-101.

KRAUSKOPF, KONRAD 1967 - INTRODUCTION TO GEOCHEMISTRY. *McGraw Hill*, *New York*, 721p.

MANHEIM, F.T., & SAYLES, F.L., 1971 - Interstitial water studies on small core samples, Deep Sea Drilling Project Leg 8. _In_ Tracey, J.I. Jr., et al., 1971 -Initial Reports of the Deep Sea Drilling Project, Volume VIII. _U.S. Govt Printing Office, Washington_, 857-870.

MULLER, G., IRION, G., & FORSTNER, U., 1972 - Formation and diagenesis of inorganic Ca-Mg carbonates in the lacustrime environment. _Naturwiss_ 59, 158-164.

MURPHY, J., & RILEY, J.P., 1962 - A modified single solution method for the determination of phosphate in natural waters. _Anal. Chim. Acta_. 27, 31-36.

PRESLEY, B.J., & KAPLAN, I.R., 1968 - Changes in dissolved sulfate, calcium and carbonate from interstitial waters of nearshore sediments. _Geochim. cosmochim. Acta_, 32, 1037-1049.

PRESLEY, B.J., and KAPLAN, I.R., 1971 - Interstitial waters chemistry, Deep Sea Drilling Project, Leg. 8. _In_ Tracey, J.I. Jr., et al., 1971 - Initial Reports of the Deep Sea Drilling Project, Volume VIII. _U.S. Govt Printing Office_, _Washington_, 853-856.

REVELLE, R.R., 1944 - Marine bottom samples collected in the Pacific Ocean by the Carnegie on its seventh cruise. _Publ. Carn. Inst. Washington_, 556, (2). 133p.

ST JOHN, B.E., 1970 - Ultra-trace element analysis of carbonate rocks by APDC - MIBK extraction and atomic absorbtion spectrophotometry _J. sediment Petrol._, 40, 537-541.

THORSTENSON, D.C., 1970 - Equilibrium distribution of small organic molecules in natural water. _Geochim. cosmochim. Acta._, 34, 745-770.

TABLE 1: COMPOSITION OF INTERSTITIAL WATERS AND ASSOCIATED SEDIMENTS FROM DEEP SEA DRILL HOLE 262. TIMOR TROUGH

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Section	4	4	5	3	4	6	1	6	5	1	6	6	1	1	6	6	6	4	5	3	6	5	6
Depth	3.50	9.50	18.96	27.00	38.00	50.50	52.50	69.50	77.50	81.00	98.00	107.50	109.50	120.44	136.00	145.50	156.44	161.50	173.94	180.44	193.00	201.00	212.00
Unit	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
POREWATER																							
ph (ft).	7.12	7.55	7.62	7.72	7.72	7.67	7.80	7.92	7.63	7.86	7.80	7.86	7.85	7.77	7.77	7.83	7.71	7.64	7.84	7.81	7.66	7.72	7.47
ph (pi)	7.12	7.50	7.40	7.48	7.62	7.40	7.55	7.48	7.52	7.65	7.90	7.64	7.64	7.53	7,54	7.61	7.46	7.47	7.52	-	-	-	-
Salinity °/oo	33.6	36.3	37.4	37.4	37.4	38.0	37.4	36.6	36.3	36.3	35.5	35.2	35.2	34.9	35.2	35.8	36.3	36.3	36.0	37.1	36.8	36.8	36.8
Alkalinity (m.e.q./L)	22.48	73.22	87.39	90.32	87.19	92.86	82.21	76.93	65.59	63.64	53.37	50.64	45.36	36.27	47.07	50.44	52.59	48.19	49.95	51.22	46.92	39.59	28.05
SO_4 ppm	500	50	50	50	100	50	50	100	50	IS	50	50	100	200	100	50	IS	50	50	50	50	50	100
Cl °/oo	19.4	19.6	19.6	19.9	19.9	19.9	19.9	19.8	20.0	IS	20.0	20.0	20.0	19.9	20.2	20.3	20.5	20.8	21.0	21.1	21.6	21.7	21.9
P_2O_5 ppm	0.41	16.0	22.5	15.1	15.5	25.6	23.3	23/3	16.0	14.2	12.8	11.0	10.6	10.8	13.5	13.8	10.4	11.5	8.9	8.4	7.95	5.75	2.85
Mg ppm	1240	1470	1530	1500	1530	1560	1500	1340	1240	1270	1160	1130	1130	1180	1180	1190	1270	1270	1290	1340	1240	1250	1080
Ca ppm	156	40	35	28	32	26	230	35	40	40	40	40	38	62	38	35	38	46	32	28	32	59	62
K ppm	365	560	575	515	585	610	600	590	560	595	525	550	595	565	575	565	575	510	555	565	565	510	525
Sr ppm	8.2	3.6	3.1	2.6	2.6	2.0	1.8	2.8	3.6	3.6	4.1	4.2	3.9	4.4	4.1	4.1	4.2	4.8	3.9	3.9	4.6	7.4	8.9
Ba ppm	0.5	13.8	9.2	7.4	7.0	6.2	4.4	6.8	9.4	9.2	11.0	10.6	10.0	6.2	12.0	14.6	15.4	16.6	15.0	15.0	17.0	21.2	23.2
Li ppm	0.14	0.13	0.13	0.15	0.15	0.15	0.15	0.17	0,19	0.20	0.22	0.22	0,22	0.21	0,21	0.25	0.23	0.21	0.25	0.26	0.26	0.27	0,34
Cu ppm	0.01	0,01	0.01	0.05	0.01	0.03	0.01	0.03	0.13	0.07	0.05	0.04	0, 03	0.09	0.04	0.07	0.04	0.04	0.04	0.04	0.02	0,06	0.03
Fe ppm	0.06	0.08	IS	0.24	0.24	0.22	0.21	IS	0.26	0.24	0.17	0.19	0.19	0.10	0.19	0.27	0.12	0.20	0.14	0.19	0,17	0.57	0.19
Mn ppm	0.60	0.009	0.09	0.05	0.05	0.06	0.05	0.05	0.06	0.07	0.06	0.05	0.07	0.09	0.08	0.07	0.08	0.06	0.05	0.05	0.06	0.24	0.09
Zn ppm	0.42	0.68	0.34	0.31	0.22	0.23	0.21	0.28	0.28	0.51	0.24	0.20	0.15	0.27	0.18	0.23	0.20	0.17	0.19	0.18	0.15	2.68	0.22
SEDIMENT																							
Fe %	2.1	2.5	2.5	2.8	2.8	2.8	2.7	3.0	3.0	3.0	3.1	3.0	2.9	3.2	2.9	3.2	2.9	3.0	2.8	3.0	2.9	3.0	3.1
Al_2O_3%	7.9	8.9	8.6	9.5	9.4	9.0	8.7	9.5	9.6	10.3	9.7	10.6	11.1	11.2	10.6	11.1	9.7	10.2	10.6	10.7	9.5	10.3	9.6
CO_2%	21.2	15.1	13.8	12.5	13.9	15.4	15.3	14.3	13.3	12.1	12.4	11.3	12.0	12.3	14.0	11.9	13.2	13.2	13.3	14.9	13.4	13.6	14.4
Ca%	18.0	14.3	13.0	11.9	12.8	14.5	14.0	13.3	12.5	10.8	10.6	10.1	11.0	11.1	12.9	10.7	12.3	11.8	12.2	13.4	13.1	12.1	13.3
Mg%	1.5	1.25	1.15	1.2	1.15	1.2	1.15	1.2	1.25	1.15	1.25	1.3	1.2	1.2	1.15	1.25	1.15	1.3	1.2	1.3	1.2	1.35	1.[illegible]
K%	0.84	1.2	1.2	1.25	1.24	1.1	1.2	1.35	1.4	1.4	1.45	1.55	1.45	1.5	1.45	1.15	1.35	1.45	1.6	1.45	1.45	1.55	1.5
Sr ppm	1000	10800	700	600	700	850	850	600	750	600	550	500	550	550	650	450	650	650	600	650	700	650	650
Ba ppm	350	450	460	420	410	410	450	400	410	400	420	380	420	410	450	400	450	460	440	470	450	470	440
Li ppm	20	30	30	30	30	30	30	30	30	30	30	40	30	40	30	40	30	40	30	40	30	40	40
Cu ppm	40	45	45	45	45	45	40	45	45	45	50	50	45	45	45	45	45	45	45	40	45	45	45
Pb ppm	15	13	10	8	5	8	13	8	10	15	20	8	5	18	15	15	10	1	10	15	8	15	10
Zn ppm	75	65	80	85	85	85	90	90	90	90	85	90	90	95	90	90	90	95	95	95	95	100	95
Co ppm	5	13	3	8	5	10	8	8	8	10	8	10	15	10	10	10	13	4	8	4	10	8	8
Ni ppm	30	40	40	40	35	35	35	40	40	40	40	45	45	45	40	40	35	30	35	40	35	40	45
Mn ppm	410	900	700	900	800	700	650	650	900	1000	1100	1100	800	1200	1200	1100	700	900	900	900	750	750	750
Cr ppm	65	75	85	70	105	80	85	75	70	85	90	90	70	65	60	90	70	65	75	90	75	95	85
P_2O_5 ppm	1168	1146	1237	1260	1260	1260	1283	1260	1260	1283	1283	1260	1260	1260	1260	1260	1168	1191	1260	1260	1146	1123	1077
CARBONATE COMPONENTS																							
% Dolomite	16.6	-	-	-	-	-	4.5	-	-	-	5.6	2.9	-	-	3.3	-	-	2.7	1.8	2.4	1.8	3.1	1.8
% Calcite	78.7	93.8	92.1	94.8	93.3	93.2	88.6	91.6	90.9	93.8	89.8	91.2	95.9	95.7	94.8	98.7	97.3	92.0	95.2	95.8	95.1	93.9	95.1
% Aragonite	4.7	6.2	7.9	5.2	6.7	6.8	6.8	8.4	9.1	6.2	4.6	5.9	4.1	4.3	2.0	1.3	2.7	5.3	3.0	1.8	3.1	3.1	3.0

Footnote: pH, salinity and alkalinity were determined on board the D.V. Glomar Challenger by Mr.J. Pine. All other chemical determinations were made by the Australian Mineral Development Laboratories; mineralogical determinations were made by the Bureau of Mineral Resources.

TABLE 1 (CONTINUED)

	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Section	6	5	5	4	3	5	5	6	6	6	4	6	6	6	5	5	5	6	5	2	3	6
Depth (m)	221.5	229.5	234.0	247.0	255.0	267.5	277.0	288.0	297.5	307.0	313.5	326.0	335.5	345.0	353.0	362.5	372.0	383.0	391.0	396.0	407.0	421.0
Unit	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	4
POREWATER																						
ph (ft)	7.47	7.61	8.04	8.17	7.58	7.65	7.45	7.50	7.67	7.44	7.50	7.75	7.70	7.83	7.71	7.38	7.73	7.98	8.09	8.01	7.68	7.41
ph (pt)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salinity °/oo	33.6	36.8	37.7	38.2	38.5	[illegible]	38.5	39.9	39.6	41.5	41.5	42.6	43.7	43.7	44.6	47.3	45.6	49.8	48.1	48.1	51.4	53.1
Alkalinity (m.e.q./L)	19.45	24.14	15.73	11.14	14.47	5.77	6.74	5.96	4.20	4.69	4.30	2.93	3.03	1.96	2.35	2.93	1.86	1.37	0.88	0.98	1.37	1.96
SO_4 ppm	100	50	50	50	50	50	240	50	50	140	50	50	240	50	100	50	IS	470	750	930	820	IS
Cl °/oo	22.2	22.4	23.2	23.6	24.1	24.2	24.1	25.3	24.1	26.1	26.4	27.1	27.3	28.2	28.2	32.3	IS	31.7	30.2	30.0	32.2	33.1
P_2O_5 ppm	1.16	2.63	2.38	2.02	1.55	0.85	2.48	1.59	0.63	0.71	0.51	0.62	1.01	0.60	0.55	0.63	0.94	0.71	0.70	0.67	0.58	1.27
Mg ppm	995	1050	1020	920	955	830	860	845	830	815	860	[illegible]	880	800	920	890	990	965	1020	965	1020	1060
Ca ppm	102	115	56	42	132	155	241	245	259	285	306	303	355	353	423	538	518	628	658	612	810	896
K ppm	535	485	605	750	570	540	460	485	485	505	480	485	460	435	430	405	415	430	425	415	415	395
Sr ppm	11.4	12.2	9.2	7.6	17.9	24.0	27.9	37.5	37.6	47.0	54.5	68.0	82.5	94.0	108	117	119	146	140	129	145	123
Ba ppm	24.7	23.1	23.8	18.4	36.1	26.9	7.6	27.8	14.0	19.4	10.4	10.4	8.4	8.8	4.0	3.0	0.8	0.6	0.7	0.4	0.5	0.4
Li ppm	0.39	0.35	0.33	0.38	0.40	0.36	0.33	0.33	0.26	0.28	0.27	0.28	0.25	0.22	0.24	0.26	0.27	0.32	0.33	0.32	0.43	0.50
Cu ppm	0.04	0.03	0.03	0.08	0.05	0.05	IS	0.09	0.22	0.12	0.05	IS	0.05	0.14	0.07	0.08	0.08	0.08	0.08	0.08	0.07	0.07
Fe ppm	0.10	0.09	0.03	0.12	0.20	0.38	0.20	0.38	0.12	0.49	0.21	0.14	0.13	0.13	0.19	0.36	0.30	0.30	0.30	0.26	0.21	0.20
Mn ppm	0.10	0.17	0.05	0.07	0.07	0.41	0.04	0.04	0.03	0.03	0.04	0.04	0.04	0.04	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05
Zn ppm	0.21	0.22	0.88	0.24	0.24	0.16	0.35	0.31	0.14	0.27	0.27	0.17	0.23	0.47	0.33	0.40	0.40	0.35	0.35	0.30	0.29	0.29
SEDIMENT																						
Fe%	2.8	2.9	2.7	2.4	1.8	1.9	1.5	1.5	2.0	1.3	1.15	2.1	1.55	2.2	0.70	0.80	0.80	0.80	1.05	0.75	0.95	0.15
Al_2O_3%	10.2	9.6	9.3	8.6	5.7	6.4	5.3	5.1	7.2	4.9	4.3	6.9	5.4	6.7	2.1	2.3	2.7	2.1	3.6	2.1	2.7	0.1
CO_2%	15.4	15.3	17.0	21.3	26.6	25.7	29.6	29.2	23.4	30.1	31.3	24.2	27.0	24.9	38.8	35.4	35.3	37.5	31.0	37.5	35.0	42.9
Ca%	14.3	14.1	15.6	19.3	23.6	27.9	27.7	26.0	21.9	27.1	28.0	21.5	24.3	21.6	32.7	30.2	30.2	30.7	26.5	31.9	28.6	31.6
Mg%	1.2	1.05	1.25	1.05	1.0	1.05	1.1	0.95	1.4	1.05	1.3	1.5	2.1	1.35	1.25	1.5	1.4	2.2	1.4	1.8	2.2	4.8
K%	1.5	1.45	1.4	1.15	0.88	0.97	0.73	0.79	1.1	0.71	0.63	1.1	0.78	1.05	0.25	0.40	0.39	0.31	0.58	0.31	0.44	0.05
Sr ppm	750	700	900	1050	1500	1500	2200	2300	1700	2200	2600	1400	1800	2100	1500	1800	1700	1400	2000	1600	1300	600
Ba ppm	420	460	480	450	440	330	310	290	260	210	180	160	150	150	90	50	100	70	100	70	90	20
Li ppm	40	30	30	30	20	30	20	20	30	20	20	30	20	20	10	10	10	10	20	10	10	1
Cu ppm	40	45	45	90	30	30	30	25	25	25	25	25	20	20	10	10	10	10	10	4	8	3
Pb ppm	20	25	1	1	15	1	5	4	5	2	8	3	10	8	15	8	10	8	10	1	2	2
Zn ppm	100	90	85	90	65	75	65	65	75	55	55	70	55	60	30	30	35	3	35	25	3	13
Co ppm	1	2	8	4	1	8	1	3	4	1	1	1	1	1	1	1	1	1	1	1	1	1
Ni ppm	45	40	40	35	40	40	30	35	30	25	35	30	15	20	10	10	13	8	10	10	8	3
Mn ppm	550	600	700	700	340	270	190	190	190	150	120	240	110	170	70	70	65	75	95	70	85	15
Cr ppm	90	90	75	30	55	50	50	55	75	45	50	65	50	65	35	25	80	50	60	35	50	5
P_2O_5 ppm	1146	1054	1375	1352	1191	1489	1375	1420	1489	1558	1512	1260	1650	1260	1398	2016	1535	2635	1489	2768	2635	1604
CARBONATE COMPONENTS																						
% Dolomite	-	-	1.2	-	5.5	4.1	6.9	5.3	10.1	6.6	11.9	19.8	31.3	8.6	11.6	20.3	15.8	36.9	14.4	22.5	23.1	63.6
% Calcite	98.4	97.6	95.1	97.1	86.0	90.9	81.7	82.8	80.9	83.9	74.1	73.8	59.5	74.6	85.8	74.8	78.9	61.9	78.4	74.1	74.4	36.1
% Aragonite	1.6	2.4	3.7	2.9	8.5	4.9	11.5	11.9	9.0	9.5	14.0	6.3	9.2	16.8	2.6	4.8	5.4	1.2	7.2	3.5	3.5	0.3

TABLE 2. AVERAGE COMPOSITION OF INTERSTITIAL WATERS AND SEA WATER

	D.S.D.P. HOLE 262				
	Samples 1-23 (upper part of hole)	Samples 24-45 (lower part of hole)	Mean value for DSDP Leg 8	Mean value for Timor Sea surface water	Standard sea water
pH	7.70	7.70	7.60	8.23	8
Salinity °/oo	36.3	42.8	35.2	34.6	35.0
Alkalinity (meq/l)	58.3	6.56	2.73	2.49	2
SO_4^{--} °/oo	0.080	0.021	2.45	2.75	2.70
Cl^- °/oo	21.1	26.9	19.6	19.9	19.4
P_2O_5 (ppm)	12.6	1.1	8.1	0.26	.17
Mg (ppm)	13.00	922	1120	1310	1298
Ca (ppm)	53	365	610	433	408
K (ppm)	559	483	390	391	388
Sr (ppm)	4.2	28.8	25.8	7.7	8.1
Ba (ppm)	11.0	12.3	0.09	0.19	0.03
Li (ppm)	0.20	0.32	0.19	0.1	0.17
Cu (ppm)	0.04	0.08	0.02	0.01	0.003
Fe (ppm)	0.20	0.22	0.09	0.08	0.01
Mn (ppm)	0.09	0.07	0.32	0.02	0.002
Zn (ppm)	0.37	0.31	-	0.07	0.01

Footnote: Mean Leg 8 values calculated from Presley & Kaplan (1971) and Manheim & Sayles (1971).

TABLE 3. MAJOR AND TRACE ELEMENT COMPOSITIONS OF THE CALCAREOUS OOZES IN D.S.D.P. HOLE 262, TIMOR TROUGH.

	D.S.D.P. HOLE 262 Samples 1-23 (upper part of hole)	Samples 24-45 (lower part of hole)	Average over entire Hole 262	Average Cenozoic sediment on Leg 27 (excluding 262)
Fe %	3.0	1.5	2.2	2.32
Al_2O_3 %	9.9	5.2	7.6	7.27
CO_2 %	13.8	28.8	21.1	20.8
Ca %	12.6	25.0	21.0	18.7
Mg %	1.23	1.54	1.38	1.10
K %	1.35	0.77	1.07	1.15
Sr ppm	1105	1572	1333	1830
Ba ppm	432	222	329	500
Li ppm	33	20		30
Cu ppm	45	22		21
Pb ppm	11	7.5	9.3	12
Zn ppm	89	54	72	85
Co ppm	9	2	6	18
Ni ppm	39	24	32	75
Mn ppm	860	228	544	2600
Cr ppm	79	54	67	600
P_2O_5 ppm	1227	1578	1403	1600
% dolomite	2.0	14.5	8.3	-
% calcite	93.2	79.1	86.2	-
% aragonite	4.8	4.4	5.5	

Table 4 . Matrix of correlation coefficients for major cations and anions in pore fluids from DSDP Hole 262. Coefficients of ± .378 or more have a 99% confidence level and are considered to be statistically significant.

	Depth	Sal	Alk	pH	C1	SO_4	P_2O_5	Cu	Fe	Mn	Zn	Mg	Ca	K	Sr	Li	Ba
Depth	1.000																
Sal	.832	1.000															
Alk	-.902	-.603	1.000														
pH	.056	.034	.101	1.000													
C1	.929	.960	-.797	-.017	1.000												
SO_4	.386	.524	-.373	.171	.470	1.000											
P_2O_5	-.825	-.531	.950	.161	.708	-.332	1.000										
Cu	.488	.353	-.481	.036	.413	.096	-.400	1.000									
Fe	.251	.257	-.125	-.086	.271	.083	-.099	.245	1.000								
Mn	-.268	-.308	-.025	-.410	-.249	.096	-.124	-.261	.000	1.000							
Zn	-.006	-.034	.003	-.026	-.014	-.028	-.056	-.006	.422	.228	1.000						
Mg	-.826	-.489	.937	.057	-.678	-.191	.866	-.565	-.154	.069	.083	1.000					
Ca	.830	.968	-.702	-.086	.950	.602	-.608	.374	.223	-.173	-.042	-.539	1.000				
K	-.626	-.653	.647	.440	-.702	-.509	.620	-.276	-.164	-.149	-.055	.491	-.774	1.000			
Sr	.843	.964	-.697	.048	.960	.610	-.598	.383	.237	-.240	-.031	.555	.965	-.749	1.000		
Li	.763	.545	-.731	.022	.631	.238	-.715	.240	.135	-.079	-.012	-.625	.571	-.308	.472	1.000	
Ba	-.083	-.474	-.034	-.064	-.337	-.494	-.132	-.070	.045	.122	.120	-.160	-.501	.402	-.519	.274	1.000

Table [illegible]. Matrix of correlation coefficients for major and trace elements in calcareous sediments from DSDP Hole 262. Coefficients of ± .378 or more have a 99% confidence level and are considered to be statistically significant.

	Depth	Al_2O_3	CO_2	Co	Ni	Cr	Pb	P_2O_5	Cu	Fe	Mn	Zn	Mg	Ca	K	Sr	Li	Ba
Depth	1.000																	
Al_2O_3	-.799	1.000																
CO_2	.849	-.985	1.000															
Co	-.704	.704	-.727	1.000														
Ni	-.712	.873	-.858	.683	1.000													
Cr	-.638	.750	-.780	.438	.656	1.000												
Pb	-.312	.371	-.368	.170	.317	.478	1.000											
P_2O_5	.618	-.715	.706	-.488	-.712	-.538	-.423	1.000										
Cu	-.873	.956	-.964	.730	.896	.712	.335	-.737	1.000									
Fe	-.796	.987	-.986	.703	.862	.765	.380	-.700	.951	1.000								
Mn	-.808	.903	-.910	.755	.777	.629	.365	-.578	.897	.900	1.000							
Zn	-.742	.967	-.942	.633	.901	.717	.313	-.733	.946	.958	.822	1.000						
Mg	.438	-.543	.527	-.339	-.614	-.519	-.246	.447	-.544	-.526	-.389	-.583	1.000					
Ca	.846	-.974	.992	-.734	-.825	-.764	-.377	.686	-.951	-.979	-.928	-.918	.434	1.000				
K	-.709	.971	-.960	.653	.877	.744	.353	-.706	.925	.969	.852	.960	-.541	-.946	1.000			
Sr	.689	-.706	.731	-.639	-.508	-.509	-.335	.410	-.696	-.723	-.816	-.620	-.020	.797	-.659	1.000		
Li	-.648	.918	-.894	.574	.856	.704	.313	-.697	.860	.912	.813	.917	-.453	-.885	.913	-.637	1.000	
Ba	-.806	.910	-.907	.713	.892	.664	.304	-.725	.952	.902	.838	.931	-.562	-.888	.890	-.664	.830	1.000

CAPTIONS TO FIGURES

1. Location of D.S.D.P. Hole 262.
2. Vertical variation in the chemical composition of pore waters from D.S.D.P. Hole 262.
3. Vertical variation in the chemical and mineralogical composition of D.S.D.P. Hole 262.
4. Location of D.S.D.P. Hole 262 samples with respect to the theoretical alkalinity-pH relations in calcareous sediments, derived by Gardner, 1973.
5. Inter-relations of various ions with salinity in the D.S.D.P. Hole 262 pore waters. Solid correlation lines have been calculated; dotted lines are approximate.
6. Inter-relations of various components in the D.S.D.P. Hole 262 pore waters. Solid correlation lines have been calculated; dotted lines are approximate.
7. A. Variation of the Mg/Ca ratio in pore waters with salinity and with position in D.S.D.P. Hole 262.
   B. Variation of the Ca/Sr ratio with Mg in D.S.D.P. Hole 262 pore waters.
8. Plot to show lack of any clear correlations between the Ca/Mg ratio and the abundance of dolomite in the sediments.
9. Summary of the three basic geochemical trends in D.S.D.P. Hole 262.

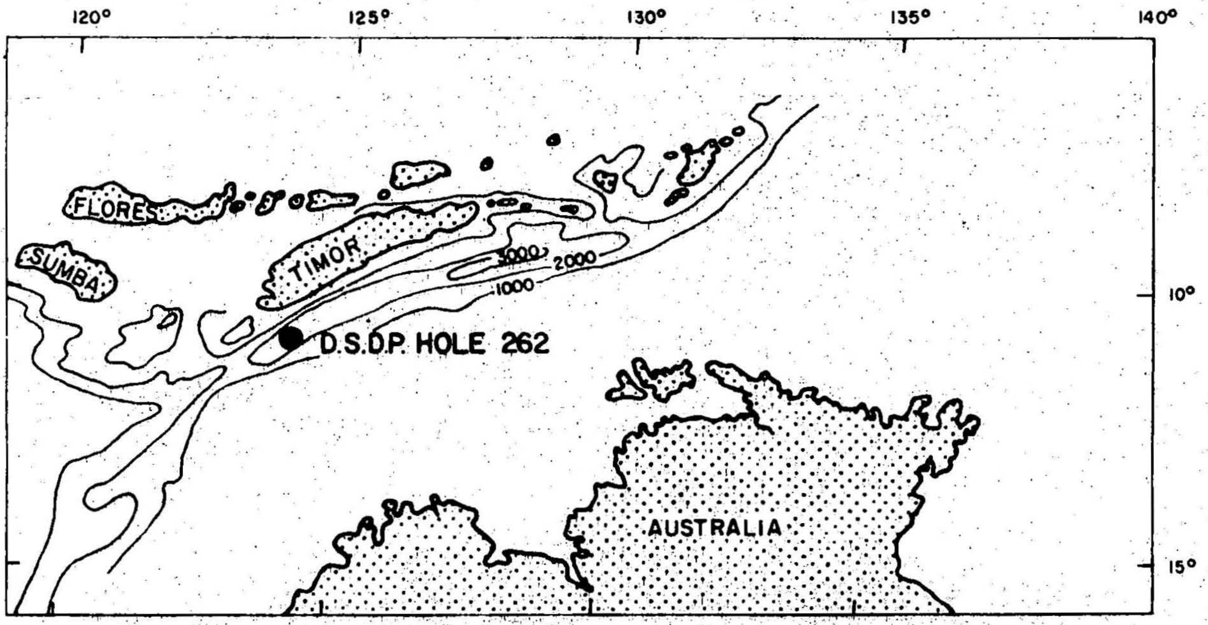

Figure I. Locality map, Site 262.

To accompany Report 1973/136.

Aus 6/103

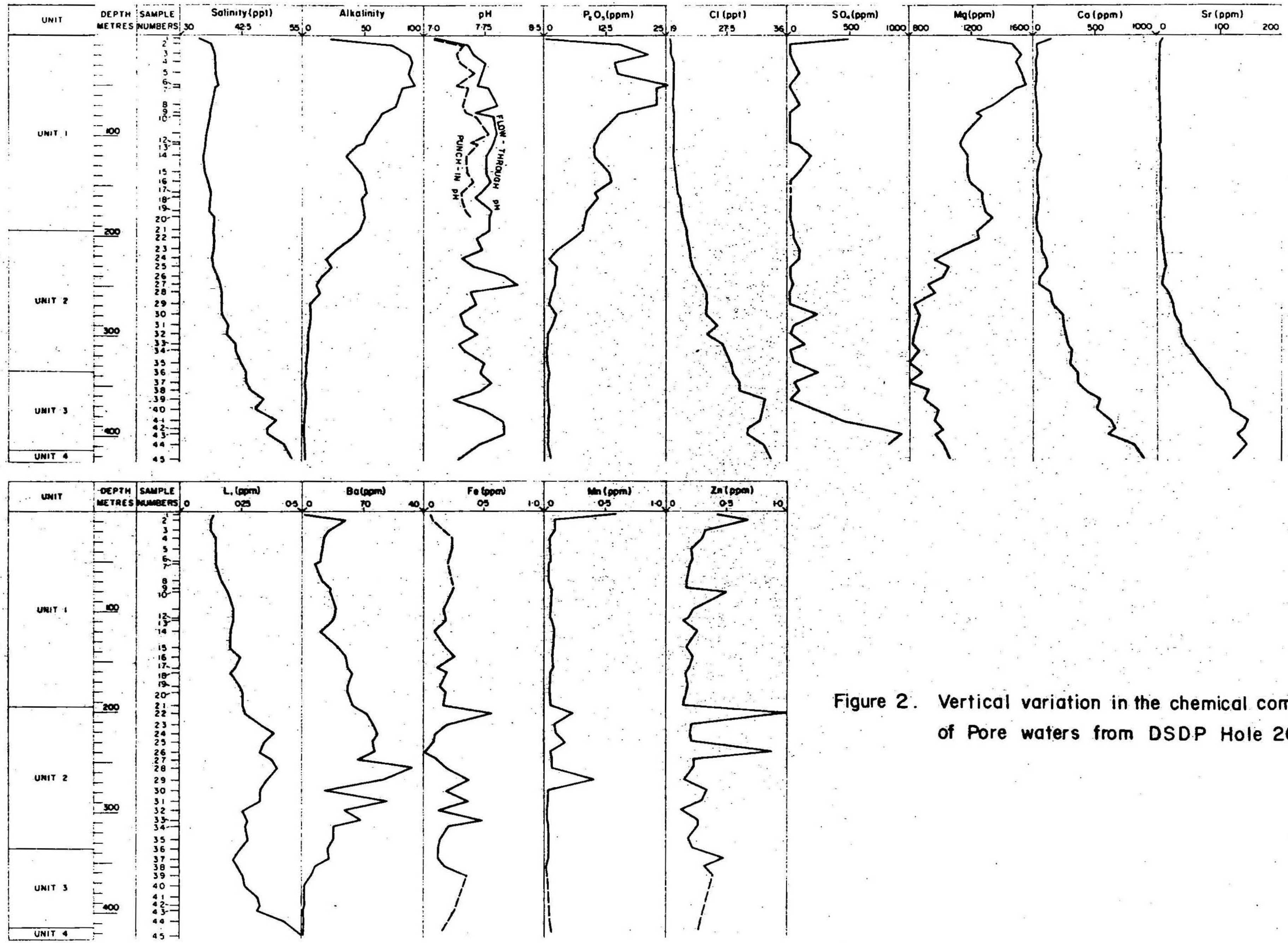

Figure 2. Vertical variation in the chemical composition of Pore waters from DSDP Hole 262.

To accompany Report 1973/136

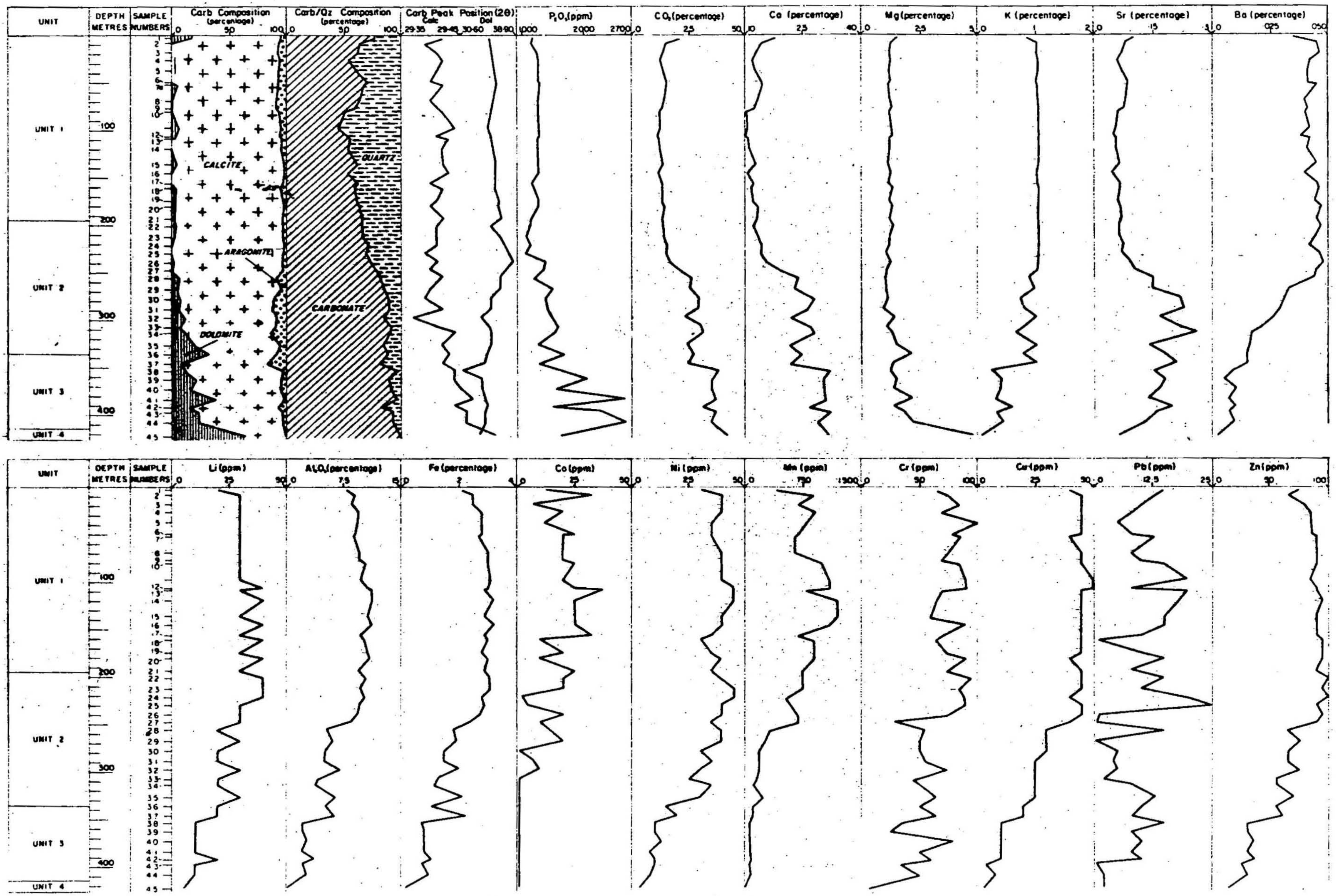

Figure 3. Vertical variation in the chemical and mineralogical composition of sediments at Site 262.

To accompany Report 1973/136

Aus 6/116

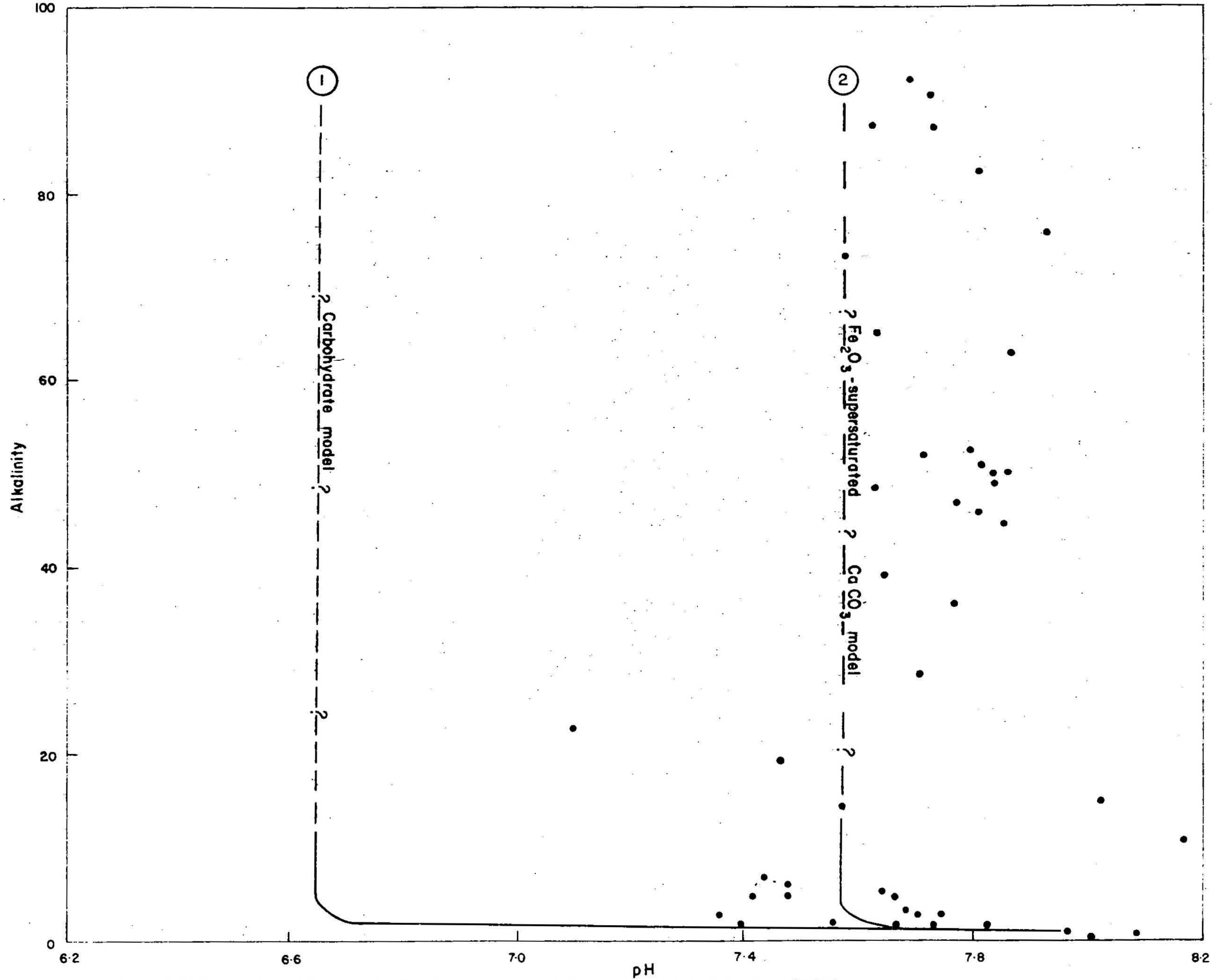

FIG 4 Locations of 262 samples with respect to the theoretical alkalinity – pH model of Gardiner (1973)

AUS 6 / 98

To accompany Report 1973/136.

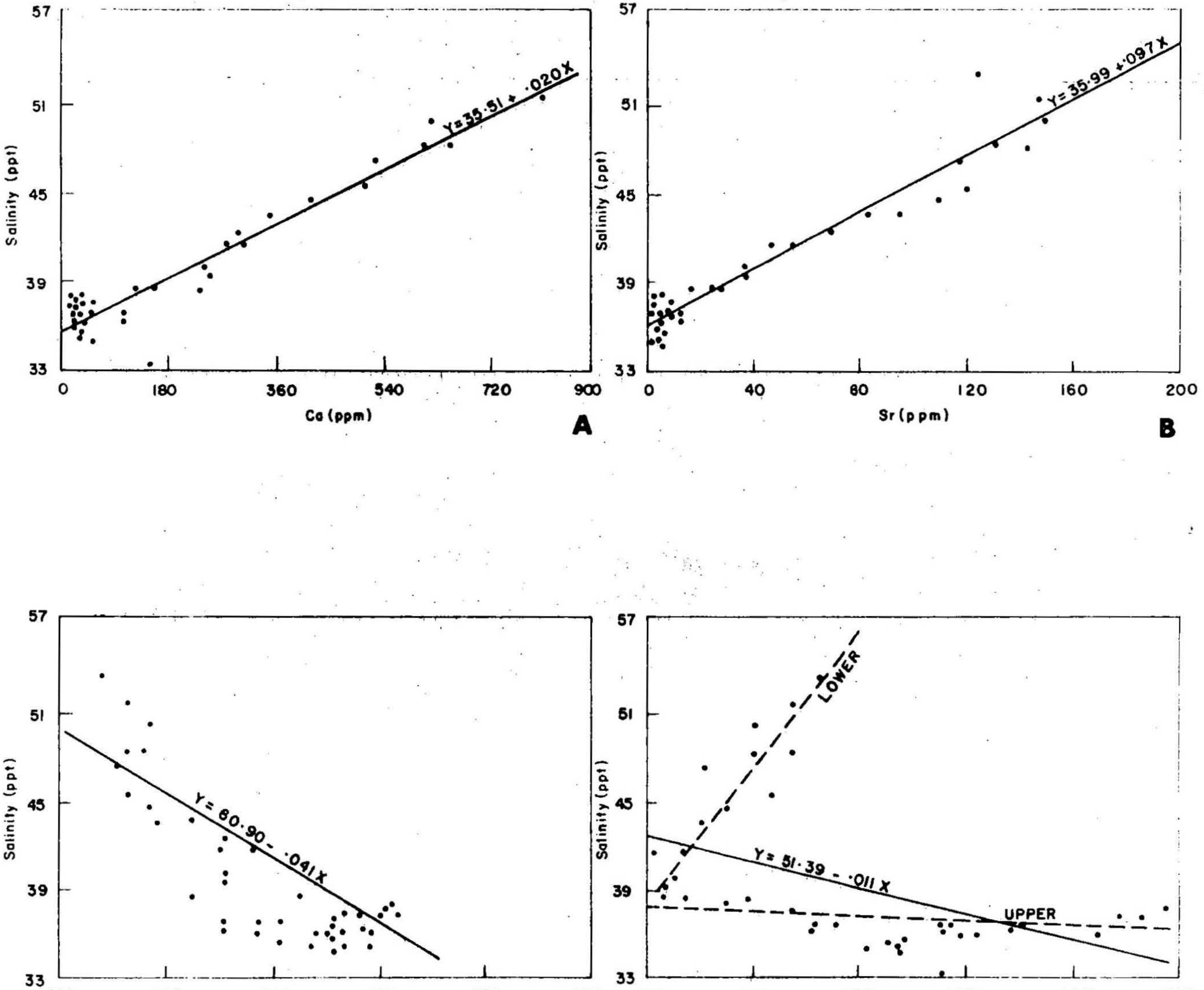

Figure 5. Inter-relationship of various ions with salinity in DSDP, Site 262, Pore waters.

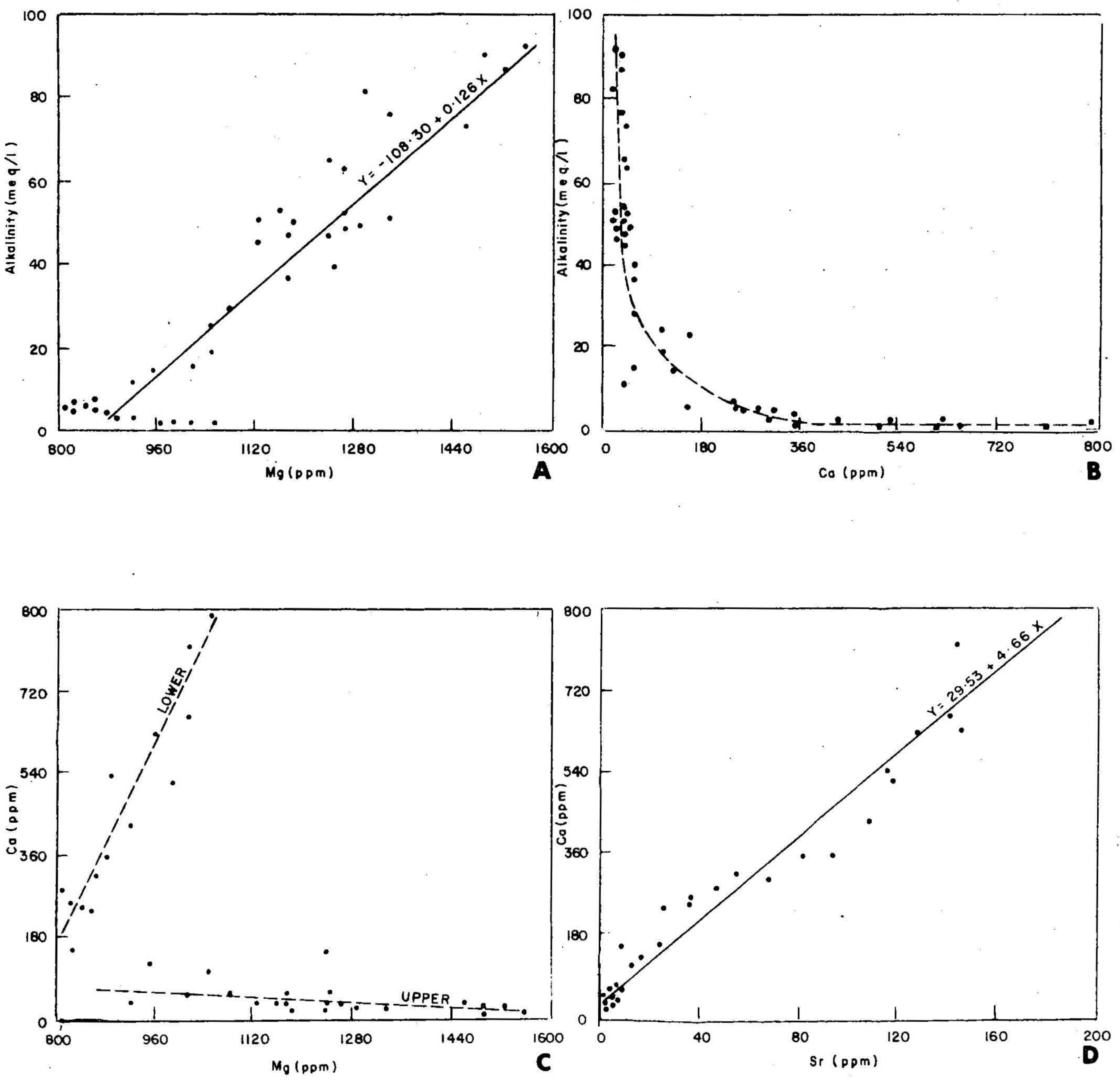

Figure 6. Inter-relationships of various pore water components from DSDP Site 262.

To accompany Report 1973/136

Aus 6/105

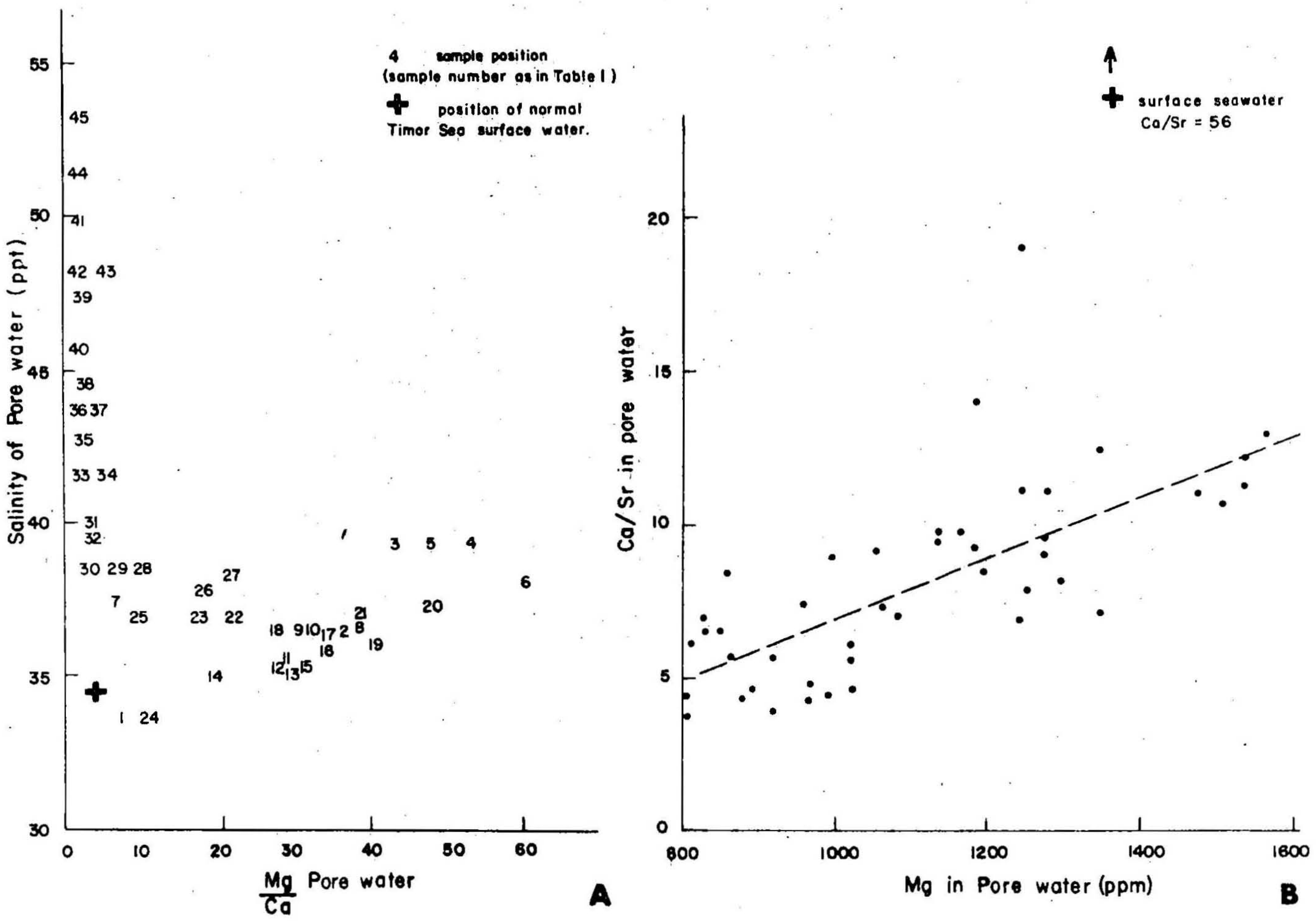

Figure 7. A. Variation of the Mg/Ca ratio with salinity and with position in DSDP Hole 262.

B. Variation of the Ca/Sr ratio, with Mg.

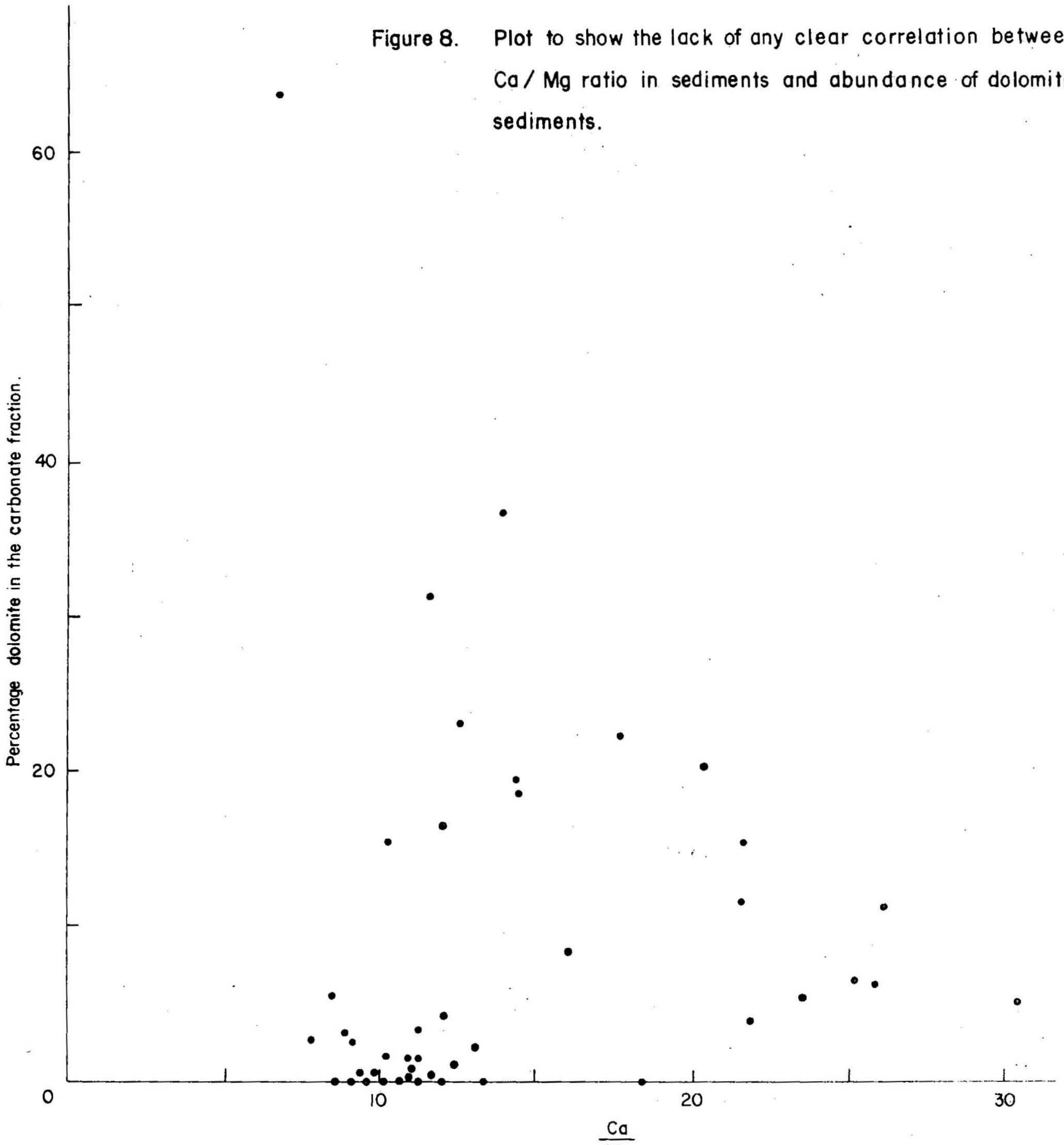

Figure 8. Plot to show the lack of any clear correlation between the Ca / Mg ratio in sediments and abundance of dolomite in sediments.

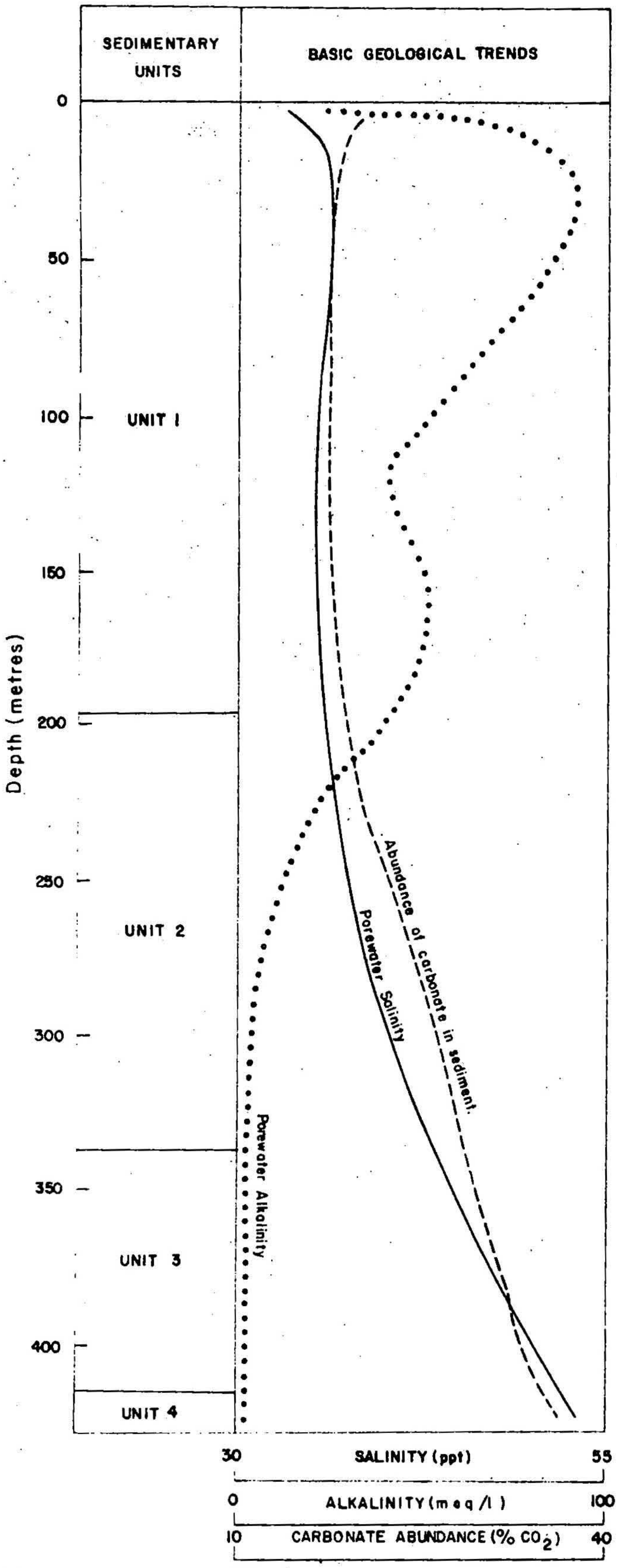

Figure 9. Summary of the three basic geochemical trends at Site 262.

To accompany Report 1973/136

AUS 6/101