E.Abramova, D.Denisov, A.Abramov

THE PROCEDURE OF CALCULATING THE ERRORS OF THE ESTIMATION OF THE SOUND VELOCITY IN SEA WATER.

The Mendeleev Chemical Technology University
Russia 125047 Moscow, Miusskaya pl. 9
Tel. (095) 9789753, Fax (095) 2004204.
E-mail: aaabramovs@mail.ru

The consideration of sea water as the solution of the mixture of four salts allows to show that the variation of the concentration of one of the four ions to 4% leads to relative variation of the deviation of the sound velocity in sea water from the sound velocity in pure water equal 4%.

In present time the influence of the concentrations of solutes on the sound velocity in sea water is taken into account with the help of the single variable – salinity S [1].

The possibility of the description of the composition of the solutes takes place if the relations of the concentration of the solutes are constant. The pointed relations for inner seas, which are not connected with the other seas or oceans or for seas connected with the other seas by narrow straits can differ from the values of the analogous relations for ocean water [1].

The method of calculating sound velocity in sea water supported by us earlier [2] does not connected with the condition mentioned above and can be used to the inner seas and seas connected with other seas and oceans by narrow straits. The binary solutions are the systems consisting of the solvent and one of the solutes.

In the first approximation sea water is considered as the solution containing four ions Na^+, Mg^{2+}, SO_4^{2-},Cl^- which concentrations in sea water exceed greately the concentrations of other ions and undissociated substances. The considered mixed solution is assumed to be an ideal isopiestic solution i.e. an ideal mixture of the binary solutions with the same value of the solvent chemical potential μ_s, by other words an ideal mixture of the binary isopiestic solutions [3,4].

The mass of pure water g_{H2O}=0,964825kg which is contained in 1 kg of sea water at S=35,072‰ corresponds to the same masses of the ions Na^+, Mg^{2+}, SO_4^{2-} which are contained in 1 kg of sea water at the same value of S [1]. The mass of the ion Cl^- has such value, which leads to the electroneutrality of the solution. The corresponding molalities of ions are given in the first line of the table 1.

This model is the basis for estimating the influence of the errors in measuring the ions concentrations on the sound velocity in seawater a_{mix}. One or two or all mass concentrations of ions Na^+, Mg^{2+}, SO_4^{2-} are given the relative variation equal 4 percents. The mass concentration of the ion Cl^- for all nine combination is chosen in such way that the electroneutrality of the solution takes place. The corresponding molalities of ions are given in the lines of the table 1 except the first one.

There are nine combinations differing between themselves by the concentration of one or two or three ions. The mass concentration of the ion Cl^- for all nine combination is chosen in such way that the electroneutrality of the solution takes place.

The use of experimental dependence of the sea water density ρ_{mix} on S [1], the relation connecting molalities of the components in isopiestic mixed m_i and binary m^*_i solutions [3,4], the relations for calculating ρ_{mix} and sound velocity in sea water a_{mix} [5] on the basis of the data referring to the isopiestic solutions allows to find the values of m_i, m^*_i, thermodynamical activity a_s, corresponding quantities for binary solutions and a_{mix}.

The first line of the table 2 contains molalities of the salts in the case when the relation between the masses of ions and the relation between the masses of ions and the mass of the pure water have the same values which take place for sea water at S= 35,072‰. Indexes 1, 2, 3, 4 correspond the salts NaCl, Na_2SO_4, $MgCl_2$, Mg_2SO_4. The second line of the table 2 and following lines contain the molalities of the salts when even one of the relation between the masses of ions differs from the value of such relation for sea water at S=35,072‰.

The column before the last contains the corresponding values of a_{mix} and the last column contains the relation of the deviation of the value of a_{mix} from the value of a_{mix1} corresponding the first line to the difference between a_{mix1} and sound velocity in the pure water a_{H2O}=1497,2 ms^{-1} [1].

It was shown [8] that the values of the sound velocity a_{mix} calculated with the help of the brief formula which does not take into account the terms including the expansion coefficients and the heat capacities of the binary isopiestic solutions differ from the values a_{mix} found at the use of the exact formulae [5] less then 0.5 m/c. So the influence of the choice of the ion which concentration in sea water at the given concentrations of the others ions can be estimated with the use of the brief formula like the influence of other variables.

We have attemt to estimate the influence of the choice of the ion which concentration at the given values of the concentrations of the other ions is calculated from the electroneutrality condition for the solution containing 6 ions Na^+, K^+, Mg^{2+}, Ca^{2+}, SO_4^{2-}, Cl^-. Early the molalities of the first five ions supposed to be equal to the molalities of these ions in sea water at the salinity S=35.0041‰ [1]. The concentration of the ion CL^- is calculated from the electroneutrality condition [2]. The salinity of the considered solution S=35.043‰.

The method supposed earlier [2] leads to the values of the molalities of the isopiestic binary solutions m^*_1=0,56727, m^*_2=0,50611, m^*_3=0,38122, m^*_4=1,02709, m^*_5=0,58285, m^*_6=0,50597, m^*_7=0,39061, where indexes 1, 2, 3, 4, 5, 6, 7, are reffered to the salts NaCl, Na_2SO_4, $MgCl_2$, Mg_2SO_4, KCl, K_2SO_4 respectively and to the molalities of the pointed salts in the mixed solution m_1=0,45126, m_2=0,01691, m_3=0,04822, m_4=0,00707, m_5=0,00001, m_6=0,00528, m_7=0,01065. calculated value of thee sound velocity a_{mix}=1536.00 mc^{-1} corresponding to S=35,04‰. Now the molalities of Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^- are supposed to be equal to the molalities of these ions in sea water at S=35.041‰. the molality of SO_4^{2-} is calculated from the electroneutrality condition.

The salinity of the considered solution is equal 35.0722‰. the use of the mentioned method leads to the molalities of the binary isopiestic solutions m^*_1=0,56727, m^*_2=0,50811, m^*_3=0,38122, m^*_4=1,02709, m^*_5=0,58285, m^*_6=0,50597, m^*_7=0,39061, and to the molalities of the mixed solution m_1=0,45045, m_2=0,01731, m_3=0,04806, m_4=0,00722, m_5=0,00121, m_6=0,00468, m_7=0,01065. the calculation value a_{mix} =1535,78 м/с is close to the value calculated earlier.

Table 1.

The molalities of ions in seawater.

Na^+	Mg^{2+}	SO_4^{2-}	Cl^-
0.485079	0.055288	0.029265	0.537125
0.504482	0.057500	0.030436	0.558610
0.504482	0.057500	0.028094	0.563293
0.504482	0.053077	0.030436	0.549764
0.504482	0.053077	0.028094	0.554447
0.465676	0.057500	0.030436	0.519804
0.465676	0.057500	0.028094	0.524486
0.465676	0.053077	0.030436	0.510958
0.465676	0.053077	0.028094	0.515640

Table 2.

The molalities of solts in seawater and sound velocity.

NaCl	Na_2SO_4	$MgCl_2$	$MgSO_4$	a_{mix}	$\frac{a_{mix} - a_{mix1}}{a_{mix} - a_{H_2O}}$
0.427185	0.028947	0.054970	0.000318	1533.65	0
0.443825	0.030329	0.057393	0.000107	1535.05	+0,038
0.448697	0.027893	0.057298	0.000202	1535.00	+0,037
0.444101	0.030191	0.052832	0.000245	1534.58	+0,026
0.448754	0.027864	0.052847	0.000230	1534.53	+0,024
0.404805	0.030436	0.057500	0.0000001	1532.77	-0,024
0.409586	0.028045	0.057450	0.000049	1532.71	-0,026
0.405366	0.030155	0.052796	0.000281	1532.29	-0,038
0.410212	0.027732	0.052714	0.000362	1532.24	-0,039

So one can say that the choice of the ion which concentration at the given concentrations of the other ions is calculated from the electroneutrality condition influences on the calculated value of the sound velocity weakly.

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