Formulae for bed density, water content and salt correction. *(In cgs)*

(I.N. McCave, Dept. Earth Sciences, Cambridge).

Data

weight wet (+sw) = x g
weight dry (+s) = y g
(x-y) = wt of water = wt of sea water-wt of salt = (sw-s) = (1-S)sw

Assumed

sediment density ρ_p = 2.65 g/cm^3 (if sed is not qtz make up density by proportion*)
salinity S = 35 g/kg = 0.035
water density ρ_w = 1.025 g/cm^3 (@ 20°C)

Derived

dry mud weight less salt **Y** = (y-Sx)/(1-S) = (y-0.035x)/0.965

salt content = (y-**Y**)/**Y** = S(x-y)/(y-Sx)

"water content" **W** = wt of salt water/wt of wet sediment
W = 1.025 (x-y)/x (usually expressed as %)

dry mud volume $\mathbf{V}_m$ $= \dfrac{\mathbf{Y}}{\rho_p} = [\mathbf{Y}/2.65]\ \text{cm}^3$

fluid volume $\mathbf{V}_w$ $= \dfrac{(x-\mathbf{Y})}{\rho_w} = [(x-\mathbf{Y})/1.025]\ \text{cm}^3$

∴ wet sample volume $\mathbf{V}_t$ $= \left[\dfrac{Y}{2.65} + \dfrac{(x-Y)}{1.025}\right] = \dfrac{2.65x - 1.625Y}{2.71625} cm^3$

porosity **P** $= \mathbf{V}_w/\mathbf{V}_t = \varepsilon/(1+\varepsilon)$

dry bulk density $= y/\mathbf{V}_t$ g/cm^3

Salt-corrected dry bulk density ρ_d $= \mathbf{Y}/\mathbf{V}_t$ g/cm^3

voids ratio ε $= \mathbf{P}/\mathbf{V}_m = \mathbf{P}/(1-\mathbf{P})$

If a dry lump of sediment is taken and carbon content C is measured and expressed as [C/dried sed wt], it is wrong unless corrected for salt content: *it should be corrected to [C/wt sed]* i.e. salt-corrected.

1 cm of core $= \mathbf{Y}/\mathbf{V}_t$ g/cm^2 of salt-free sed.

with sedimentation rate SR cm/ka, and mass accumulation rate MAR g/cm^2/ka

MAR = SR ($\mathbf{Y}/\mathbf{V}_t$) g/cm^2/ka

Summary formulae: $\rho_d = \rho_s (1 - P)$
$\rho_t = \Delta_\rho (1 - P) + \rho_w$
$\rho_t = \rho_d \Delta_\rho$
$\rho_d = (\rho_t - \rho_w) \rho_s/\Delta_\rho$

ρ_w = density of water, ρ_s = sediment grain density, $\Delta_\rho = (\rho_s - \rho_w)$, ρ_t = total wet bulk density x/$\mathbf{V}_t$, ρ_d = salt-corrected dry bulk density (concentration), P = porosity.

Worked example: weight wet = 10 g
weight dry = 7 g

Y = (7-0.035x10)/0.965 = <u>6.891</u>.g.

water content **W** = 0.3075 or 30.8%

Salt content of dry mud + salt = 0.0158 (a ratio)

dry mud vol $\mathbf{V}_m$ $= \frac{6.891}{2.65} = 2.600\ cm^3$

fluid vol $\mathbf{V}_w$ = 3.033 cm^3

wet sample vol $\mathbf{V}_t$ = 5.634 cm^3

porosity **P** = 0.538

voids ratio ε = 1.16

dry bulk ρ = 1.243. g/cm^3

Salt-corr. dry bulk ρ_d = 1.223 g/cm^3

$\therefore$ 1 cm core = 1.223 g/cm^2 dry sed.

$\therefore$ 5 cm/ka SR = 6.1 g/cm^2/ka dry sed MAR.

if say 9.1% by weight is C <u>on a salt-free basis</u> by wt., then MAR of C = 0.56 g/cm^2/ka.

To express ρ_d in terms of water content **W**

$$\rho_d = 2.65 \frac{(1 - 1.011\mathbf{W})}{(1 + 1.603\mathbf{W})}$$ (**W** was a fraction)

(with **W** = 0.3075 above gives ρ_d = 1.223 g/cm^3 as required).

* 'by proportion' means, normally proportion of opal to (qtz+CO_3) , ρ_P= 2.1 vs 2.65

McCave 1.92, revised 3/05

Formulae for bed density, water content and salt correction. *(In SI)*

(I.N. McCave, Dept. Earth Sciences, Cambridge).

Data

weight wet (+sw) = x kg
weight dry (+s) = y kg
(x-y) = wt of water = wt of sea water-wt of salt = (sw-s) = (1-S)sw

Assumed

sediment density ρ_p = 2650 kg/m^3
salinity S = 35 g/kg = 0.035
seawater density ρ_w = 1025 kg/m^3 (@ 20°C)

Derived

dry mud weight less salt **Y** = (y-Sx)/(1-S) = (y-0.035x)/0.965

salt content = (y-**Y**)/**Y** = S(x-y)/(y-Sx)

"water content" **W** = wt of salt water/wt of wet sediment
W = 1025 (x-y)/x (usually expressed as %)

dry mud volume $\mathbf{V}_m$ $= \dfrac{\mathbf{Y}}{\rho_p} = [\mathbf{Y}/2650]\ \mathrm{m}^3$

fluid volume $\mathbf{V}_w$ $= \dfrac{(x-\mathbf{Y})}{\rho_w} = [(x-\mathbf{Y})/1025]\ \mathrm{m}^3$

∴ wet sample volume $\mathbf{V}_t$ $= \left[\dfrac{Y}{2650} + \dfrac{(x-Y)}{1025}\right] = \dfrac{2650x - 1625Y}{2716.25} m^3$

porosity **P** $= \mathbf{V}_w/\mathbf{V}_t = \varepsilon/(1+\varepsilon)$

dry bulk density $= y/\mathbf{V}_t$ kg/m^3

Salt-corrected dry bulk density ρ_d $= \mathbf{Y}/\mathbf{V}_t$ kg/m^3

voids ratio ε $= P/\mathbf{V}_m = P/(1-P)$

If a dry lump of sediment is taken and carbon content C is measured and expressed as C/(wt sed + salt), it is wrong <u>unless corrected for salt content</u>: *it should be corrected to [C/wt sed].*

1 cm of core $= 0.01\mathbf{Y}/\mathbf{V}_t$ kg/m^2 of salt-free sed.

with sedimentation rate SR m/ma (=mm/ka), and mass accumulation rate MAR kg/m^2/Ma

MAR = SR $(\mathbf{Y}/\mathbf{V}_t)$ kg/m^2/Ma

Summary formulae: $\rho_d = \rho_s\,(1 - P)$
$\rho_t = \Delta_\rho\,(1 - P) + \rho_w$
$\rho_t = \rho_d\,\Delta_\rho$
$\rho_d = (\rho_t - \rho_w)\,\rho_s/\Delta_\rho$

ρ_w = density of water, ρ_s = sediment grain density, $\Delta_\rho = (\rho_s - \rho_w)$, ρ_t = total wet bulk density x/$\mathbf{V}_t$, ρ_d = salt-corrected dry bulk density (concentration), P = porosity.

Worked example: weight wet = $10\mathrm{x}10^{-3}$ kg
weight dry = $7\mathrm{x}10^{-3}$ kg

Y = $(7-0.035\mathrm{x}10)\mathrm{x}\ 10^{-3}/0.965 = \underline{6.891\mathrm{x}10^{-3}}$ kg

water content **W** = 0.3075 or 30.8%

Salt content of dry mud + salt = 0.0158 (a ratio)

dry mud vol $\mathbf{V}_m$ = $\dfrac{6.891\mathrm{x}10^{-3}}{2650} = 2.600\mathrm{x}10^{-6}\ \mathrm{m}^3$

fluid vol $\mathbf{V}_w$ = $3.033\mathrm{x}10^{-6}\ \mathrm{m}^3$

wet sample vol $\mathbf{V}_t$ = $5.634\mathrm{x}10^{-6}\ \mathrm{m}^3$

porosity **P** = 0.538

voids ratio ε = 1.16

dry bulk ρ = 1243 $\mathrm{kg/m^3}$

Salt-corr. dry bulk ρ_d = 1223 $\mathrm{kg/m^3}$

$\therefore$ 1 cm core = 12.23 $\mathrm{kg/m^2}$ dry sed.

$\therefore$ 50 mm/ka SR = 61.2 $\mathrm{kg/m^2}$/ma dry sed MAR.

if say 9.1% by weight is Carbon <u>on a salt-free basis</u> by wt., then MAR of C = 5.6 $\mathrm{kg/m^2}$/ma.

To express ρ_d in terms of water content **W**

$$\rho_d = 2650\,\frac{(1 - 1.011\mathbf{W})}{(1 + 1.603\mathbf{W})} \qquad (\mathbf{W}\text{ was a fraction})$$

(with **W** = 0.3075 above gives ρ_d = 1223 $\mathrm{kg/m^3}$ as required).

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