Package ‘Rmbal’

July 6, 2020

Title Estimate Original Hydrocarbon in Place and Reservoir Performance

Version 0.1.0

Date 2020-07-05

Description Material balance analysis for oil and gas reservoirs. Initial hydrocarbon in place and production forecasts are generated using PVT (Pressure-Volume-Temperature) and historical injection and production data. The current version provides history-match and prediction models for dry-gas, wet-gas, gas condensate, volatile oil, and black oil reservoirs. Walsh, M. P., Ansah, Joseph, and Raghavan, Rajagopal (1994) <doi:10.2118/27684-MS>. Walsh, M. P., Ansah, Joseph, and Raghavan, Rajagopal (1994) <doi:10.2118/27728-MS>. Walsh, M. P. (1995) <doi:10.2118/95-01-07>.

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URL https://susaenergy.github.io/Rmbal_ws/

Imports pracma, gsl, magrittr, minpack.lm, Rdpack

RdMacros Rdpack

Suggests Rpvt, Rrelperm, knitr, rmarkdown, testthat, ggplot2, dplyr, tidyr

Language en-US

Encoding UTF-8

LazyData TRUE

VignetteBuilder knitr

RoxygenNote 7.1.0

NeedsCompilation no

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R topics documented:

`mbal_forecast_gas` *Generic function for performance forecasting of a gas reservoir*

Description

Generate a data frame of reservoir production estimates, and fluids saturations and liquid dropout in the gas leg according to the class of 'forecast_lst' and 'time_lst' objects

Usage

```
mbal_forecast_gas(forecast_lst, time_lst)
```

Arguments

`forecast_lst`	a list object of class 'forecast_gas'
`time_lst`	a list object of class 'time/date'

Value

a data frame with estimates for saturation of fluids, liquid dropout, gas-oil ratio, recovery factor, and drive indices over a range of given pressures

References

Walsh MP, Lake LW (2003). *A Generalized Approach to Primary Hydrocarbon Recovery*, 1st edition. Elsevier Ltd. ISBN 9780444506832, https://www.elsevier.com/books/a-generalized-approach-to-primary-walsh/978-0-444-50683-2.

Walsh MP, Ansah J, Raghavan R (1994). "New, generalized material balance as an equation of a straight line: Part 1- Applications to undersaturated, volumetric reservoirs." *Proceedings of the Permian Basin Oil \& Gas Recovery Conference*, 549–564. doi: 10.2118/27684MS.

Walsh MP, Ansah J, Raghavan R (1994). "New, generalized material balance as an equation of a straight line: part 2- Applications to saturated and non-volumetric reservoirs." *Proceedings of the Permian Basin Oil \& Gas Recovery Conference*, 859–865. doi: 10.2118/27728MS.

Walsh MP (1995). "A Generalized Approach to Reservoir Material Balance Calculations." *Journal of Canadian Petroleum Technology*, **34**(01), 10. ISSN 0021-9487, doi: 10.2118/950107, https://doi.org/10.2118/95-01-07.

Fetkovich MJ, Reese DE, Whitson CH (1998). "Application of a General Material Balance for High-Pressure Gas Reservoirs (includes associated paper 51360)." *SPE Journal*, **3**(01), 3–13. ISSN 1086-055X, doi: 10.2118/22921PA, https://doi.org/10.2118/22921-PA.

Examples

```
p_pvt <- c(3700, 3650, 3400, 3100, 2800, 2500, 2200, 1900, 1600, 1300, 1000,
700,  600, 400)

Bo <- c(10.057, 2.417, 2.192, 1.916, 1.736, 1.617, 1.504, 1.416, 1.326, 1.268,
1.205, 1.149, 1.131, 1.093)

Rv <- c(84.11765, 84.11765, 70.5, 56.2, 46.5, 39.5, 33.8, 29.9, 27.3, 25.5, 25.9,
28.3, 29.8, 33.5) / 1e6

Rs <- c(11566, 2378, 2010, 1569, 1272, 1067, 873, 719, 565, 461, 349, 249, 218,
141)

Bg <- c(0.87, 0.88, 0.92, 0.99, 1.08, 1.20, 1.35, 1.56, 1.85, 2.28, 2.95, 4.09,
4.68, 6.53) / 1000

cw <- 3e-6

Bwi <- 10.05

Bw <- Bwi * exp(cw * (p_pvt[1] - p_pvt))

muo <- c(0.0612, 0.062, 0.1338, 0.1826, 0.2354, 0.3001, 0.3764, 0.4781, 0.6041,
0.7746, 1.0295, 1.358, 1.855, 2.500)

mug <- c(0.0612, 0.062, 0.0554, 0.0436, 0.0368, 0.0308, 0.0261, 0.0222, 0.0191,
```

```
0.0166, 0.0148, 0.0135, 0.0125, 0.0115)

muw <- rep(0.25, length(p_pvt))

pvt_table <- data.frame(p = p_pvt, Bo = Bo, Rs = Rs, Rv = Rv, Bg = Bg, Bw = Bw,
 muo = muo, mug = mug, muw = muw)

rel_perm <- as.data.frame(Rrelperm::kr2p_gl(SWCON = 0.2, SOIRG = 0.15,
SORG = 0.15, SGCON = 0.05, SGCRIT = 0.05, KRGCL = 1, KROGCG = 1,
NG = 3.16, NOG = 2.74, NP = 101))

colnames(rel_perm) <- c("Sg", "Sl", "Krg", "Krog")

p <- c(3700, 3650, 3400, 3100, 2800, 2500, 2200, 1900, 1600, 1300, 1000, 700,
600)

Gi <- rep(0, length.out = length(p))

wf <- rep(1, length.out = length(p))

forecast_lst <- mbal_forecast_param_gas(input_unit = "Field",
output_unit = "Field", G = 2.41e10, phi = 0.1, swi = 0.2, pd = 3650,
p = p, pvt = pvt_table, M = 0, cf = 2e-6, wf = wf,
rel_perm = rel_perm)

time_lst <- mbal_time(c(1:length(p)), "year")

mbal_forecast_results <- mbal_forecast_gas(forecast_lst, time_lst)

dplyr::glimpse(mbal_forecast_results)
```

---

mbal_forecast_gas.volumetric_forecast_gas

S3 method for class 'mbal_forecast_gas'

Description

Return a data frame with estimates for saturation of fluids, liquid dropout, gas-oil ratio, recovery factor, and drive indices over a range of given pressures for a volumetric reservoir

Usage

```
## S3 method for class 'volumetric_forecast_gas'
mbal_forecast_gas(forecast_lst, time_lst)
```

Arguments

forecast_lst	a list object of class 'forecast_gas'
time_lst	a list object of class 'time'

Value

a data frame with estimates for saturation of fluids, liquid dropout, gas-oil ratio, recovery factor, and drive indices over a range of given pressures for a volumetric reservoir

---

`mbal_forecast_oil` *Generic function for performance forecasting of an oil reservoir*

Description

Generate a data frame of reservoir production estimates, and fluids saturations and liquid dropout in the oil leg according to the class of 'forecast_lst' and 'time_lst' objects

Usage

```
mbal_forecast_oil(forecast_lst, time_lst)
```

Arguments

`forecast_lst`	a list object of class 'forecast_oil'
`time_lst`	a list object of class 'time/date'

Value

a data frame with estimates for saturation of fluids, liquid dropout, gas-oil ratio, recovery factor, and drive indices over a range of given pressures

References

Walsh MP, Lake LW (2003). *A Generalized Approach to Primary Hydrocarbon Recovery*, 1st edition. Elsevier Ltd. ISBN 9780444506832, https://www.elsevier.com/books/a-generalized-approach-to-primary-walsh/978-0-444-50683-2.

Walsh MP, Ansah J, Raghavan R (1994). "New, generalized material balance as an equation of a straight line: Part 1- Applications to undersaturated, volumetric reservoirs." *Proceedings of the Permian Basin Oil \& Gas Recovery Conference*, 549–564. doi: 10.2118/27684MS.

Walsh MP, Ansah J, Raghavan R (1994). "New, generalized material balance as an equation of a straight line: part 2- Applications to saturated and non-volumetric reservoirs." *Proceedings of the Permian Basin Oil \& Gas Recovery Conference*, 859–865. doi: 10.2118/27728MS.

Walsh MP (1995). "A Generalized Approach to Reservoir Material Balance Calculations." *Journal of Canadian Petroleum Technology*, **34**(01), 10. ISSN 0021-9487, doi: 10.2118/950107, https://doi.org/10.2118/95-01-07.

Examples

```
p_pvt <- c(3330, 3150, 3000, 2850, 2700, 2550, 2400)

Bo <- c(1.2511, 1.2353, 1.2222, 1.2122, 1.2022, 1.1922, 1.1822)

Rs <- c(510, 477, 450, 425, 401, 375, 352)

Bg <- c(0.00087, 0.00092, 0.00096, 0.00101, 0.00107, 0.00113, 0.00120)

cw <- 2e-6

Bwi <- 1.0

Bw <- Bwi * exp(cw * (p_pvt[1] - p_pvt))

Rv <- rep(0, length(p_pvt))

muo <- rep(0.5, length(p_pvt))

muw <- rep(0.25, length(p_pvt))

mug <- rep(0.02, length(p_pvt))

pvt_table <- data.frame(p = p_pvt, Bo = Bo, Rs = Rs, Rv = Rv, Bg = Bg,
                       Bw = Bw, muo = muo, mug = mug, muw = muw)

rel_perm <- as.data.frame(Rrelperm::kr2p_gl(SWCON = 0.2, SOIRG = 0.10,
SORG = 0.10, SGCON = 0.05, SGCRIT = 0.05, KRGCL = 0.3, KROGCG = 1,
NG = 0.93, NOG = 10, NP = 101))

colnames(rel_perm) <- c("Sg", "Sl", "Krg", "Krog")

p <- c(3330, 3150, 3000, 2850, 2700, 2550, 2400)

Gi <- rep(0, length.out = length(p))

wf <- c(1, 1, 1, 0, 1, 0, 1)

forecast_lst <- mbal_forecast_param_oil(input_unit = "Field",
output_unit = "Field", N = 1.37e8, m = 0.377, phi = 0.2, swi = 0.2, Gi = Gi,
pb = 3330, p = p, pvt = pvt_table, cf = 0, wf = wf, sorg = 0.2,
rel_perm = rel_perm)

time_lst <- mbal_time(c(0, 365, 730, 1095, 1460, 1825, 2190), "day")

mbal_forecast_results <- mbal_forecast_oil(forecast_lst, time_lst)

dplyr::glimpse(mbal_forecast_results)
```

mbal_forecast_oil.gas_cap_forecast_oil

S3 method for class 'mbal_forecast_oil'

Description

Return a data frame with estimates for saturation of fluids, liquid dropout, gas-oil ratio, recovery factor, and drive indices over a range of given pressures for a gas_cap_drive oil reservoir

Usage

```
## S3 method for class 'gas_cap_forecast_oil'
mbal_forecast_oil(forecast_lst, time_lst)
```

Arguments

forecast_lst	a list object of class 'forecast_oil'
time_lst	a list object of class 'time'

Value

a data frame with estimates for saturation of fluids, liquid dropout, gas-oil ratio, recovery factor, and drive indices over a range of given pressures for a gas_cap_drive oil reservoir

mbal_forecast_oil.volumetric_forecast_oil

S3 method for class 'mbal_forecast_oil'

Description

Return a data frame with estimates for saturation of fluids, liquid dropout, gas-oil ratio, recovery factor, and drive indices over a range of given pressures for a volumetric oil reservoir

Usage

```
## S3 method for class 'volumetric_forecast_oil'
mbal_forecast_oil(forecast_lst, time_lst)
```

Arguments

forecast_lst	a list object of class 'forecast_oil'
time_lst	a list object of class 'time'

Value

a data frame with estimates for saturation of fluids, liquid dropout, gas-oil ratio, recovery factor, and drive indices over a range of given pressures for a volumetric oil reservoir

mbal_forecast_param_gas
A list object of class 'forecast_gas' for material balance analysis

Description

Create an object of class 'forecast_gas'

Usage

```
mbal_forecast_param_gas(
  input_unit = "Field",
  output_unit = "Field",
  G = NULL,
  phi = NULL,
  swi = NULL,
  pd = NULL,
  p = NULL,
  pvt = NULL,
  cf = NULL,
  M = NULL,
  wf = NULL,
  rel_perm = NULL
)
```

Arguments

input_unit	a unit system for parameters, only the character string 'Field' is accepted
output_unit	a unit system for properties, only the character string 'Field' is accepted
G	original gas in place, SCF.
phi	reservoir porosity, a numeric fraction
swi	initial water saturation in the reservoir, a numeric fraction
pd	dew point pressure, a numeric value, psi
p	reservoir pressure, a numeric vector, psi
pvt	a data frame of PVT properties including pressure 'p' in 'psi', oil formation volume factor 'Bo' in 'bbl/stb', solution gas-oil ratio 'Rs' in 'scf/stb', oil viscosity 'muo' in 'cp', volatilized oil-gas ratio 'Rv' in 'stb/scf', gas formation volume factor 'Bg' in 'bbl/scf', gas viscosity 'mug' in 'cp', water formation volume factor 'Bw' in 'bbl/stb', and water viscosity 'muw' in 'cp'
cf	formation compressibility, a numeric value or vector, 1/psi
M	ratio of non-net-pay pore volume to the reservoir (net-pay) volume, a numeric fraction.
wf	weight factor, a numeric vector of zeros and ones. A zero value excludes the entire row of reservoir history data at a particular time from the material balance analysis

`rel_perm` a data frame with four columns: gas saturation 'Sg', liquid saturation 'Sl', gas relative permeability 'Krg', and oil relative permeability 'Krog'

Value

a list of class 'forecast_gas' with all the required parameters for the mbal_forecast_gas() S3 methods

Examples

```
p_pvt <- c(3700, 3650, 3400, 3100, 2800, 2500, 2200, 1900, 1600, 1300, 1000,
700,  600, 400)
Bo <- c(10.057, 2.417, 2.192, 1.916, 1.736, 1.617, 1.504, 1.416, 1.326, 1.268,
1.205, 1.149, 1.131, 1.093)

Rv <- c(84.11765, 84.11765, 70.5, 56.2, 46.5, 39.5, 33.8, 29.9, 27.3, 25.5, 25.9,
28.3, 29.8, 33.5) / 1e6

Rs <- c(11566, 2378, 2010, 1569, 1272, 1067, 873, 719, 565, 461, 349, 249, 218,
141)

Bg <- c(0.87, 0.88, 0.92, 0.99, 1.08, 1.20, 1.35, 1.56, 1.85, 2.28, 2.95, 4.09,
4.68, 6.53) / 1000

cw <- 3e-6

Bwi <- 10.05

Bw <- Bwi * exp(cw * (p_pvt[1] - p_pvt))

muo <- c(0.0612, 0.062, 0.1338, 0.1826, 0.2354, 0.3001, 0.3764, 0.4781, 0.6041,
0.7746, 1.0295, 1.358, 1.855, 2.500)

mug <- c(0.0612, 0.062, 0.0554, 0.0436, 0.0368, 0.0308, 0.0261, 0.0222, 0.0191,
0.0166, 0.0148, 0.0135, 0.0125, 0.0115)

muw <- rep(0.25, length(p_pvt))

pvt_table <- data.frame(p = p_pvt, Bo = Bo, Rs = Rs, Rv = Rv, Bg = Bg, Bw = Bw,
 muo = muo, mug = mug, muw = muw)

rel_perm <- as.data.frame(Rrelperm::kr2p_gl(SWCON = 0.2, SOIRG = 0.15,
SORG = 0.15, SGCON = 0.05, SGCRIT = 0.05, KRGCL = 1, KROGCG = 1,
NG = 3.16, NOG = 2.74, NP = 101))

colnames(rel_perm) <- c("Sg", "Sl", "Krg", "Krog")

p <- c(3700, 3650, 3400, 3100, 2800, 2500, 2200, 1900, 1600, 1300, 1000, 700,
600)

wf <- rep(1, length.out = length(p))

forecast_lst <- mbal_forecast_param_gas(input_unit = "Field",
output_unit = "Field", G = 2.41e10, phi = 0.1, swi = 0.2, pd = 3650,
```

```
p = p, pvt = pvt_table, M = 0, cf = 2e-6, wf = wf,
rel_perm = rel_perm)

dplyr::glimpse(forecast_lst)
```

`mbal_forecast_param_oil` *A list object of class 'forecast_oil' for material balance analysis*

Description

Create an object of class 'forecast_oil'

Usage

```
mbal_forecast_param_oil(
  input_unit = "Field",
  output_unit = "Field",
  N = NULL,
  m = NULL,
  phi = NULL,
  swi = NULL,
  Gi = NULL,
  pb = NULL,
  p = NULL,
  pvt = NULL,
  cf = NULL,
  wf = NULL,
  sorg = NULL,
  rel_perm = NULL
)
```

Arguments

`input_unit`	a unit system for parameters, only the character string 'Field' is accepted
`output_unit`	a unit system for properties, only the character string 'Field' is accepted
`N`	original oil in place, STB
`m`	ratio of original gas cap volume to original oil leg volume, a numeric fraction
`phi`	reservoir porosity, a numeric fraction
`swi`	initial water saturation in the reservoir, a numeric fraction
`Gi`	cumulative gas injection, SCF
`pb`	bubble point pressure, a numeric value, psi
`p`	reservoir pressure, a numeric vector, psi

pvt	a data frame of PVT properties including pressure 'p' in 'psi', oil formation volume factor 'Bo' in 'bbl/stb', solution gas-oil ratio 'Rs' in 'scf/stb', oil viscosity 'muo' in 'cp', volatilized oil-gas ratio 'Rv' in 'stb/scf', gas formation volume factor 'Bg' in 'bbl/scf', gas viscosity 'mug' in 'cp', water formation volume factor 'Bw' in 'bbl/stb', and water viscosity 'muw' in 'cp'
cf	formation compressibility, a numeric value or vector, 1/psi
wf	weight factor, a numeric vector of zeros and ones. A zero value excludes the entire row of reservoir history data at a particular time from the material balance analysis
sorg	residual oil saturation in gas invaded zone (gas cap expansion or gas injection), a numeric fraction
rel_perm	a data frame with four columns: gas saturation 'Sg', liquid saturation 'Sl', gas relative permeability 'Krg', and oil relative permeability 'Krog'

Value

a list of class 'forecast_oil' with all the required parameters for the mbal_forecast_oil() S3 methods

Examples

```
p_pvt <- c(3330, 3150, 3000, 2850, 2700, 2550, 2400)

Bo <- c(1.2511, 1.2353, 1.2222, 1.2122, 1.2022, 1.1922, 1.1822)

Rs <- c(510, 477, 450, 425, 401, 375, 352)

Bg <- c(0.00087, 0.00092, 0.00096, 0.00101, 0.00107, 0.00113, 0.00120)

cw <- 2e-6

Bwi <- 1.0

Bw <- Bwi * exp(cw * (p_pvt[1] - p_pvt))

Rv <- rep(0, length(p_pvt))

muo <- rep(0.5, length(p_pvt))

muw <- rep(0.25, length(p_pvt))

mug <- rep(0.02, length(p_pvt))

pvt_table <- data.frame(p = p_pvt, Bo = Bo, Rs = Rs, Rv = Rv, Bg = Bg,
                        Bw = Bw, muo = muo, mug = mug, muw = muw)

rel_perm <- as.data.frame(Rrelperm::kr2p_gl(SWCON = 0.2, SOIRG = 0.10,
SORG = 0.10, SGCON = 0.05, SGCRIT = 0.05, KRGCL = 0.3, KROGCG = 1,
NG = 0.93, NOG = 10, NP = 101))

colnames(rel_perm) <- c("Sg", "Sl", "Krg", "Krog")
```

```
p <- c(3330, 3150, 3000, 2850, 2700, 2550, 2400)

Gi <- rep(0, length.out = length(p))

wf <- c(1, 1, 1, 0, 1, 0, 1)

forecast_lst <- mbal_forecast_param_oil(input_unit = "Field",
output_unit = "Field", N = 1.37e8, m = 0.377, phi = 0.2, swi = 0.2, Gi = Gi,
pb = 3330, p = p, pvt = pvt_table, cf = 0, wf = wf, sorg = 0.2,
rel_perm = rel_perm)

dplyr::glimpse(forecast_lst)
```

`mbal_optim_gas` *Generic function for predicting unknown parameters of a material balance model*

Description

Generate a list of class 'mbal_gas' with estimates for the unknown parameters of the material balance model according to the class of 'optim_lst' and 'time_lst' objects

Usage

```
mbal_optim_gas(optim_lst, time_lst)
```

Arguments

`optim_lst`	a list object of class 'optimization_gas'
`time_lst`	a list object of class 'time/date'

Value

a list of class 'mbal_gas' with estimates for the unknown parameters of the material balance model according to the class of 'optim_lst' and 'time_lst' objects

References

Walsh MP, Lake LW (2003). *A Generalized Approach to Primary Hydrocarbon Recovery*, 1st edition. Elsevier Ltd. ISBN 9780444506832, https://www.elsevier.com/books/a-generalized-approach-to-primary-walsh/978-0-444-50683-2.

Walsh MP, Ansah J, Raghavan R (1994). "New, generalized material balance as an equation of a straight line: Part 1- Applications to undersaturated, volumetric reservoirs." *Proceedings of the Permian Basin Oil \& Gas Recovery Conference*, 549–564. doi: 10.2118/27684MS.

Walsh MP, Ansah J, Raghavan R (1994). "New, generalized material balance as an equation of a straight line: part 2- Applications to saturated and non-volumetric reservoirs." *Proceedings of the Permian Basin Oil \& Gas Recovery Conference*, 859–865. doi: 10.2118/27728MS.

Walsh MP (1995). “A Generalized Approach to Reservoir Material Balance Calculations.” *Journal of Canadian Petroleum Technology*, **34**(01), 10. ISSN 0021-9487, doi: 10.2118/950107, https://doi.org/10.2118/95-01-07.

Fetkovich MJ, Reese DE, Whitson CH (1998). “Application of a General Material Balance for High-Pressure Gas Reservoirs (includes associated paper 51360).” *SPE Journal*, **3**(01), 3–13. ISSN 1086-055X, doi: 10.2118/22921PA, https://doi.org/10.2118/22921-PA.

Examples

```
p_pvt <- c(3700, 3650, 3400, 3100, 2800, 2500, 2200, 1900, 1600, 1300, 1000,
700,  600, 400)
Bo <- c(10.057, 2.417, 2.192, 1.916, 1.736, 1.617, 1.504, 1.416, 1.326, 1.268,
1.205, 1.149, 1.131, 1.093)

Rv <- c(84.11765, 84.11765, 70.5, 56.2, 46.5, 39.5, 33.8, 29.9, 27.3, 25.5, 25.9,
28.3, 29.8, 33.5) / 1e6

Rs <- c(11566, 2378, 2010, 1569, 1272, 1067, 873, 719, 565, 461, 349, 249, 218,
141)

Bg <- c(0.87, 0.88, 0.92, 0.99, 1.08, 1.20, 1.35, 1.56, 1.85, 2.28, 2.95, 4.09,
4.68, 6.53) / 1000

cw <- 3e-6

Bwi <- 10.05

Bw <- Bwi * exp(cw * (p_pvt[1] - p_pvt))

muo <- c(0.0612, 0.062, 0.1338, 0.1826, 0.2354, 0.3001, 0.3764, 0.4781, 0.6041,
0.7746, 1.0295, 1.358, 1.855, 2.500)

mug <- c(0.0612, 0.062, 0.0554, 0.0436, 0.0368, 0.0308, 0.0261, 0.0222, 0.0191,
0.0166, 0.0148, 0.0135, 0.0125, 0.0115)

muw <- rep(0.25, length(p_pvt))

pvt_table <- data.frame(p = p_pvt, Bo = Bo, Rs = Rs, Rv = Rv, Bg = Bg, Bw = Bw,
 muo = muo, mug = mug, muw = muw)

p <- c(3700, 3650, 3400, 3100, 2800, 2500, 2200, 1900, 1600, 1300, 1000, 700,
600)

We <- rep(0, length.out = length(p))

Np <- c(0, 28.6, 93, 231, 270, 379, 481, 517.2, 549, 580, 675, 755, 803) *1e3

Gp <- c(0, 0.34, 1.2, 3.3, 4.3, 6.6, 9.1, 10.5, 12, 12.8, 16.4, 19.1, 20.5) * 1e9

Wp <- rep(0, length.out = length(p))

Wi <- rep(0, length.out = length(p))
```

```
wf <- rep(1, length.out = length(p))

mbal_optim_gas_lst <- mbal_optim_param_gas(input_unit = "Field",
output_unit = "Field", unknown_param = "G", aquifer_model = NULL,
phi = 0.1, swi = 0.2, Np = Np, Gp = Gp, Wp = Wp, Wi = Wi, We = We, pd = 3650,
p = p, pvt = pvt_table, M = 0, cf = 2e-6, wf = wf, sgrw = 0.15)

time_lst <- mbal_time(c(1:length(p)), "year")

optim_results <- mbal_optim_gas(mbal_optim_gas_lst, time_lst)

dplyr::glimpse(optim_results)
```

`mbal_optim_gas.volumetric_optim_gas`

S3 method for class 'mbal_optim_gas'

Description

Generate a list of class 'mbal_gas' with estimates for the unknown parameters of a volumetric gas reservoir

Usage

```
## S3 method for class 'volumetric_optim_gas'
mbal_optim_gas(optim_lst, time_lst)
```

Arguments

`optim_lst`	a list object of class 'optimization_gas'
`time_lst`	a list object of class 'time'

Value

a list of class 'mbal_gas' with estimates for the unknown parameters of a volumetric gas reservoir

---

`mbal_optim_gas.water_drive_optim_gas`

S3 method for class 'mbal_optim_gas'

Description

Generate a list of class 'mbal_gas' with estimates for the unknown parameters of a water_drive gas reservoir

Usage

```
## S3 method for class 'water_drive_optim_gas'
mbal_optim_gas(optim_lst, time_lst)
```

Arguments

`optim_lst`	a list object of class 'optimization_gas'
`time_lst`	a list object of class 'time'

Value

a list of class 'mbal_gas' with estimates for the unknown parameters of a water_drive gas reservoir

---

`mbal_optim_oil` *Generic function for predicting unknown parameters of a material balance model*

Description

Generate a list of class 'mbal_oil' with estimates for the unknown parameters of the material balance model according to the class of 'optim_lst' and 'time_lst' objects

Usage

```
mbal_optim_oil(optim_lst, time_lst)
```

Arguments

`optim_lst`	a list object of class 'optimization_oil'
`time_lst`	a list object of class 'time/date'

Value

a list of class 'mbal_oil' with estimates for the unknown parameters of the material balance model according to the class of 'optim_lst' and 'time_lst' objects

References

Walsh MP, Lake LW (2003). *A Generalized Approach to Primary Hydrocarbon Recovery*, 1st edition. Elsevier Ltd. ISBN 9780444506832, https://www.elsevier.com/books/a-generalized-approach-to-primary-walsh/978-0-444-50683-2.

Walsh MP, Ansah J, Raghavan R (1994). "New, generalized material balance as an equation of a straight line: Part 1- Applications to undersaturated, volumetric reservoirs." *Proceedings of the Permian Basin Oil \& Gas Recovery Conference*, 549–564. doi: 10.2118/27684MS.

Walsh MP, Ansah J, Raghavan R (1994). "New, generalized material balance as an equation of a straight line: part 2- Applications to saturated and non-volumetric reservoirs." *Proceedings of the Permian Basin Oil \& Gas Recovery Conference*, 859–865. doi: 10.2118/27728MS.

Walsh MP (1995). "A Generalized Approach to Reservoir Material Balance Calculations." *Journal of Canadian Petroleum Technology*, **34**(01), 10. ISSN 0021-9487, doi: 10.2118/950107, https://doi.org/10.2118/95-01-07.

Examples

```
p_pvt <- c(3330, 3150, 3000, 2850, 2700, 2550, 2400)

Bo <- c(1.2511, 1.2353, 1.2222, 1.2122, 1.2022, 1.1922, 1.1822)

Rs <- c(510, 477, 450, 425, 401, 375, 352)

Bg <- c(0.00087, 0.00092, 0.00096, 0.00101, 0.00107, 0.00113, 0.00120)

cw <- 2e-6

Bwi <- 1.0

Bw <- Bwi * exp(cw * (p_pvt[1] - p_pvt))

Rv <- rep(0, length(p_pvt))

muo <- rep(0.5, length(p_pvt))

muw <- rep(0.25, length(p_pvt))

mug <- rep(0.02, length(p_pvt))

pvt_table <- data.frame(p = p_pvt, Bo = Bo, Rs = Rs, Rv = Rv, Bg = Bg,
                        Bw = Bw, muo = muo, mug = mug, muw = muw)

p <- c(3330, 3150, 3000, 2850, 2700, 2550, 2400)

We <- rep(0, length.out = length(p))

Np <- c(0, 3.295, 5.903, 8.852, 11.503, 14.513, 17.730) * 1e6

Rp <- c(0, 1050, 1060, 1160, 1235, 1265, 1300)

Wp <- rep(0, length.out = length(p))

Wi <- rep(0, length.out = length(p))

Gi <- rep(0, length.out = length(p))

wf <- c(1, 1, 1, 0, 1, 0, 1)

mbal_optim_oil_lst <- mbal_optim_param_oil(input_unit = "Field",
output_unit = "Field", unknown_param = "N_m", aquifer_model = NULL,
phi = 0.2, swi = 0.2, Np = Np,Rp = Rp, Wp = Wp, Gi = Gi, Wi = Wi,
We = We, pb = 3330, p = p, pvt = pvt_table, cf = 0, wf = wf,
sorg = 0.2, sorw = 0)
```

```
time_lst <- mbal_time(c(0, 365, 730, 1095, 1460, 1825, 2190), "day")

optim_results <- mbal_optim_oil(mbal_optim_oil_lst, time_lst)

dplyr::glimpse(optim_results)
```

---

mbal_optim_oil.combination_optim_oil

S3 method for class 'mbal_optim_oil'

Description

Generate a list of class 'mbal_oil' with estimates for the unknown parameters of a combination_drive oil reservoir

Usage

```
## S3 method for class 'combination_optim_oil'
mbal_optim_oil(optim_lst, time_lst)
```

Arguments

optim_lst	a list object of class 'optimization_oil'
time_lst	a list object of class 'time'

Value

a list of class 'mbal_oil' with estimates for the unknown parameters of a combination_drive oil reservoir

---

mbal_optim_oil.gas_cap_optim_oil

S3 method for class 'mbal_optim_oil'

Description

Generate a list of class 'mbal_oil' with estimates for the unknown parameters of a gas_cap_drive oil reservoir

Usage

```
## S3 method for class 'gas_cap_optim_oil'
mbal_optim_oil(optim_lst, time_lst)
```

Arguments

`optim_lst`	a list object of class 'optimization_oil'
`time_lst`	a list object of class 'time'

Value

a list of class 'mbal_oil' with estimates for the unknown parameters of a gas_cap_drive oil reservoir

---

mbal_optim_oil.volumetric_optim_oil

S3 method for class 'mbal_optim_oil'

Description

Generate a list of class 'mbal_oil' with estimates for the unknown parameters of a volumetric oil reservoir

Usage

```
## S3 method for class 'volumetric_optim_oil'
mbal_optim_oil(optim_lst, time_lst)
```

Arguments

`optim_lst`	a list object of class 'optimization_oil'
`time_lst`	a list object of class 'time'

Value

a list of class 'mbal_oil' with estimates for the unknown parameters of a volumetric oil reservoir

---

mbal_optim_oil.water_drive_optim_oil

S3 method for class 'mbal_optim_oil'

Description

Generate a list of class 'mbal_oil' with estimates for the unknown parameters of a water_drive oil reservoir

Usage

```
## S3 method for class 'water_drive_optim_oil'
mbal_optim_oil(optim_lst, time_lst)
```

Arguments

`optim_lst`	a list object of class 'optimization_oil'
`time_lst`	a list object of class 'time'

Value

a list of class 'mbal_oil' with estimates for the unknown parameters of a water_drive oil reservoir

---

`mbal_optim_param_gas` *A list object of class 'optimization_gas' for material balance analysis*

Description

Create an object of class 'optimization_gas'

Usage

```
mbal_optim_param_gas(
  input_unit = "Field",
  output_unit = "Field",
  unknown_param = NULL,
  aquifer_model = NULL,
  G = NULL,
  phi = NULL,
  swi = NULL,
  Np = NULL,
  Gp = NULL,
  Wp = NULL,
  Wi = NULL,
  We = NULL,
  pd = NULL,
  p = NULL,
  pvt = NULL,
  cf = NULL,
  M = NULL,
  phi_a = NULL,
  perm_h_a = NULL,
  perm_v_a = NULL,
  h_a = NULL,
  r_a = NULL,
  r_R = NULL,
  w_a = NULL,
  l_a = NULL,
  tetha = NULL,
  muw_a = NULL,
  cw_a = NULL,
```

```
  cf_a = NULL,
  wf = NULL,
  sgrw = NULL,
  mult_len = NULL,
  lower = NULL,
  upper = NULL,
  control = NULL
)
```

Arguments

input_unit	a unit system for parameters, only the character string 'Field' is accepted
output_unit	a unit system for properties, only the character string 'Field' is accepted
unknown_param	a character string showing the unknown parameter(s). One of the following options: 'G', 'We', 'M', or 'G_M'
aquifer_model	defaulted to NULL, otherwise must be a character string, one of the following eight options: 'uss_rad_edge', 'uss_rad_bottom', 'uss_lin_edge', 'uss_lin_bottom', 'pss_rad_edge', 'pss_lin_edge', 'pss_lin_bottom', 'pot'. For further information about each model, please see 'Raquifer' package reference manual (https://cran.r-project.org/web/packages/Raquifer/index.html)
G	original gas in place, SCF. If unknown, a NULL value must be assigned
phi	reservoir porosity, a numeric fraction
swi	initial water saturation in the reservoir, a numeric fraction
Np	cumulative oil production, STB
Gp	cumulative gas production, SCF
Wp	cumulative water production, STB
Wi	cumulative water injection, STB
We	cumulative aquifer water influx, BBL. If unknown, a NULL value must be assigned
pd	dew point pressure, a numeric value, psi
p	reservoir pressure, a numeric vector, psi
pvt	a data frame of PVT properties including pressure 'p' in 'psi', oil formation volume factor 'Bo' in 'bbl/stb', solution gas-oil ratio 'Rs' in 'scf/stb', oil viscosity 'muo' in 'cp', volatilized oil-gas ratio 'Rv' in 'stb/scf', gas formation volume factor 'Bg' in 'bbl/scf', gas viscosity 'mug' in 'cp', water formation volume factor 'Bw' in 'bbl/stb', and water viscosity 'muw' in 'cp'
cf	formation compressibility, a numeric value or vector, 1/psi
M	ratio of non-net-pay pore volume to the reservoir (net-pay) volume, a numeric fraction. If unknown, a NULL value must be assigned.
phi_a	aquifer porosity, a numeric fraction
perm_h_a	aquifer horizontal permeability, md. Used in 'uss_rad_edge', 'uss_rad_bottom', 'uss_lin_edge', 'pss_rad_edge', 'pss_lin_edge' and 'pot' aquifer models

perm_v_a — vertical permeability, md. Used in 'uss_rad_bottom', 'uss_lin_bottom', 'pss_rad_bottom', and 'pss_lin_bottom' aquifer models

h_a — aquifer height, ft

r_a — aquifer radius, ft. Used in 'uss_rad_edge', 'uss_rad_bottom', 'pss_rad_edge', and 'pot' aquifer models

r_R — reservoir radius, ft. Used in 'uss_rad_edge', 'uss_rad_bottom', 'pss_rad_edge', and 'pot' aquifer models

w_a — aquifer width, ft. Used in 'uss_lin_edge', 'uss_lin_bottom', 'pss_lin_edge', and 'pss_lin_bottom' aquifer models

l_a — aquifer length, ft. Used in 'uss_lin_edge', 'uss_lin_bottom', 'pss_lin_edge', and 'pss_lin_bottom' aquifer models

tetha — fraction of reservoir encircled by the aquifer, degrees. Used in 'uss_rad_edge', 'pss_rad_edge', and 'pot' aquifer models

muw_a — aquifer water viscosity, cp

cw_a — aquifer water compressibility, a numeric value, 1/psi

cf_a — aquifer formation compressibility, a numeric value, 1/psi

wf — weight factor, a numeric vector of zeros and ones. A zero value excludes the entire row of reservoir history data at a particular time from the material balance analysis

sgrw — residual gas saturation in water invaded zone (aquifer encroachment or water injection), a numeric fraction

mult_len — a numeric vector of initial estimates for the 'aquifer_model' parameters A vector of length one for the 'pot' aquifer model. It applies as a multiplier to the radius of the aquifer A vector of length two for the 'uss_rad_edge', and 'pss_rad_edge' aquifer models. The first parameter is applied as a multiplier to the aquifer radius, and the second parameter is applied as a multiplier to the aquifer horizontal permeability A vector of length two for the 'uss_lin_edge', and 'pss_lin_edge' aquifer models. The first parameter is applied as a multiplier to the aquifer length, and the second parameter is applied as a multiplier to the aquifer horizontal permeability A vector of length two for the 'uss_lin_bottom', and 'pss_lin_bottom' aquifer models. The first parameter is applied as a multiplier to the aquifer height, and the second parameter is applied as a multiplier to the aquifer vertical permeability A vector of length three for the 'uss_rad_bottom' aquifer model. The first parameter is applied as a multiplier to the aquifer radius, the second parameter is applied as a multiplier to the aquifer horizontal permeability, and the third parameter is applied as a multiplier to the aquifer vertical permeability

lower — an optional numeric vector of lower bounds for the 'aquifer_model' parameters. See 'minpack.lm' package for details

upper — an optional numeric vector of upper bounds for the 'aquifer_model' parameters. See 'minpack.lm' package for details

control — an optional list of control settings. See 'minpack.lm' package for details

Value

a list of class 'mbal_gas' with all the required parameters for the mbal_perform_gas() S3 methods

Examples

```
p_pvt <- c(3700, 3650, 3400, 3100, 2800, 2500, 2200, 1900, 1600, 1300, 1000,
700,  600, 400)
Bo <- c(10.057, 2.417, 2.192, 1.916, 1.736, 1.617, 1.504, 1.416, 1.326, 1.268,
1.205, 1.149, 1.131, 1.093)

Rv <- c(84.11765, 84.11765, 70.5, 56.2, 46.5, 39.5, 33.8, 29.9, 27.3, 25.5, 25.9,
28.3, 29.8, 33.5) / 1e6

Rs <- c(11566, 2378, 2010, 1569, 1272, 1067, 873, 719, 565, 461, 349, 249, 218,
141)

Bg <- c(0.87, 0.88, 0.92, 0.99, 1.08, 1.20, 1.35, 1.56, 1.85, 2.28, 2.95, 4.09,
4.68, 6.53) / 1000

cw <- 3e-6

Bwi <- 10.05

Bw <- Bwi * exp(cw * (p_pvt[1] - p_pvt))

muo <- c(0.0612, 0.062, 0.1338, 0.1826, 0.2354, 0.3001, 0.3764, 0.4781, 0.6041,
0.7746, 1.0295, 1.358, 1.855, 2.500)

mug <- c(0.0612, 0.062, 0.0554, 0.0436, 0.0368, 0.0308, 0.0261, 0.0222, 0.0191,
0.0166, 0.0148, 0.0135, 0.0125, 0.0115)

muw <- rep(0.25, length(p_pvt))

pvt_table <- data.frame(p = p_pvt, Bo = Bo, Rs = Rs, Rv = Rv, Bg = Bg, Bw = Bw,
 muo = muo, mug = mug, muw = muw)

p <- c(3700, 3650, 3400, 3100, 2800, 2500, 2200, 1900, 1600, 1300, 1000, 700,
600)

We <- rep(0, length.out = length(p))

Np <- c(0, 28.6, 93, 231, 270, 379, 481, 517.2, 549, 580, 675, 755, 803) *1e3

Gp <- c(0, 0.34, 1.2, 3.3, 4.3, 6.6, 9.1, 10.5, 12, 12.8, 16.4, 19.1, 20.5) * 1e9

Wp <- rep(0, length.out = length(p))

Wi <- rep(0, length.out = length(p))

wf <- rep(1, length.out = length(p))

mbal_optim_gas_lst <- mbal_optim_param_gas(input_unit = "Field",
```

```
output_unit = "Field", unknown_param = "G", aquifer_model = NULL,
phi = 0.1, swi = 0.2, Np = Np, Gp = Gp, Wp = Wp, Wi = Wi, We = We, pd = 3650,
p = p, pvt = pvt_table, M = 0, cf = 2e-6, wf = wf, sgrw = 0.15)

dplyr::glimpse(mbal_optim_gas_lst)
```

`mbal_optim_param_oil` *A list object of class 'optimization_oil' for material balance analysis*

Description

Create an object of class 'optimization_oil'

Usage

```
mbal_optim_param_oil(
  input_unit = "Field",
  output_unit = "Field",
  unknown_param = NULL,
  aquifer_model = NULL,
  N = NULL,
  m = NULL,
  phi = NULL,
  swi = NULL,
  Np = NULL,
  Rp = NULL,
  Wp = NULL,
  Gi = NULL,
  Wi = NULL,
  We = NULL,
  pb = NULL,
  p = NULL,
  pvt = NULL,
  cf = NULL,
  phi_a = NULL,
  perm_h_a = NULL,
  perm_v_a = NULL,
  h_a = NULL,
  r_a = NULL,
  r_R = NULL,
  w_a = NULL,
  l_a = NULL,
  tetha = NULL,
  muw_a = NULL,
  cw_a = NULL,
  cf_a = NULL,
  wf = NULL,
```

```
  sorg = NULL,
  sorw = NULL,
  mult_len = NULL,
  lower = NULL,
  upper = NULL,
  control = NULL
)
```

Arguments

input_unit	a unit system for parameters, only the character string 'Field' is accepted
output_unit	a unit system for properties, only the character string 'Field' is accepted
unknown_param	a character string showing the unknown parameter(s). One of the following options: 'N', 'm', 'We', or 'N_m'
aquifer_model	defaulted to NULL, otherwise must be a character string, one of the following eight options: 'uss_rad_edge', 'uss_rad_bottom', 'uss_lin_edge', 'uss_lin_bottom', 'pss_rad_edge', 'pss_lin_edge', 'pss_lin_bottom', 'pot'. For further information about each model, please see 'Raquifer' package reference manual (https://cran.r-project.org/web/packages/Raquifer/index.html)
N	original oil in place, STB. If unknown, a NULL value must be assigned
m	ratio of original gas cap volume to original oil leg volume, a numeric. If unknown, a NULL value must be assigned
phi	reservoir porosity, a numeric fraction
swi	initial water saturation in the reservoir, a numeric fraction
Np	cumulative oil production, STB
Rp	ratio of cumulative produced gas to cumulative produced oil
Wp	cumulative water production, STB
Gi	cumulative gas injection, SCF
Wi	cumulative water injection, STB
We	cumulative aquifer water influx, BBL. If unknown, a NULL value must be assigned
pb	bubble point pressure, a numeric value, psi
p	reservoir pressure, a numeric vector, psi
pvt	a data frame of PVT properties including pressure 'p' in 'psi', oil formation volume factor 'Bo' in 'bbl/stb', solution gas-oil ratio 'Rs' in 'scf/stb', oil viscosity 'muo' in 'cp', volatilized oil-gas ratio 'Rv' in 'stb/scf', gas formation volume factor 'Bg' in 'bbl/scf', gas viscosity 'mug' in 'cp', water formation volume factor 'Bw' in 'bbl/stb', and water viscosity 'muw' in 'cp'
cf	formation compressibility, a numeric value or vector, 1/psi
phi_a	aquifer porosity, a numeric fraction
perm_h_a	aquifer horizontal permeability, md. Used in 'uss_rad_edge', 'uss_rad_bottom', 'uss_lin_edge', 'pss_rad_edge', 'pss_lin_edge' and 'pot' aquifer models

perm_v_a
: vertical permeability, md. Used in 'uss_rad_bottom', 'uss_lin_bottom', 'pss_rad_bottom', and 'pss_lin_bottom' aquifer models

h_a
: aquifer height, ft

r_a
: aquifer radius, ft. Used in 'uss_rad_edge', 'uss_rad_bottom', 'pss_rad_edge', and 'pot' aquifer models

r_R
: reservoir radius, ft. Used in 'uss_rad_edge', 'uss_rad_bottom', 'pss_rad_edge', and 'pot' aquifer models

w_a
: aquifer width, ft. Used in 'uss_lin_edge', 'uss_lin_bottom', 'pss_lin_edge', and 'pss_lin_bottom' aquifer models

l_a
: aquifer length, ft. Used in 'uss_lin_edge', 'uss_lin_bottom', 'pss_lin_edge', and 'pss_lin_bottom' aquifer models

tetha
: fraction of reservoir encircled by the aquifer, degrees. Used in 'uss_rad_edge', 'pss_rad_edge', and 'pot' aquifer models

muw_a
: aquifer water viscosity, cp

cw_a
: aquifer water compressibility, a numeric value, 1/psi

cf_a
: aquifer formation compressibility, a numeric value, 1/psi

wf
: weight factor, a numeric vector of zeros and ones. A zero value excludes the entire row of reservoir history data at a particular time from the material balance analysis

sorg
: residual oil saturation in gas invaded zone (gas cap expansion or gas injection), a numeric fraction

sorw
: residual oil saturation in water invaded zone (aquifer encroachment or water injection), a numeric fraction

mult_len
: a numeric vector of initial estimates for the 'aquifer_model' parameters A vector of length one for the 'pot' aquifer model. It applies as a multiplier to the radius of the aquifer A vector of length two for the 'uss_rad_edge', and 'pss_rad_edge' aquifer models. The first parameter is applied as a multiplier to the aquifer radius, and the second parameter is applied as a multiplier to the aquifer horizontal permeability A vector of length two for the 'uss_lin_edge', and 'pss_lin_edge' aquifer models. The first parameter is applied as a multiplier to the aquifer length, and the second parameter is applied as a multiplier to the aquifer horizontal permeability A vector of length two for the 'uss_lin_bottom', and 'pss_lin_bottom' aquifer models. The first parameter is applied as a multiplier to the aquifer height, and the second parameter is applied as a multiplier to the aquifer vertical permeability A vector of length three for the 'uss_rad_bottom' aquifer model. The first parameter is applied as a multiplier to the aquifer radius, the second parameter is applied as a multiplier to the aquifer horizontal permeability, and the third parameter is applied as a multiplier to the aquifer vertical permeability

lower
: an optional numeric vector of lower bounds for the 'aquifer_model' parameters. See 'minpack.lm' package for details

upper
: an optional numeric vector of upper bounds for the 'aquifer_model' parameters. See 'minpack.lm' package for details

control
: an optional list of control settings. See 'minpack.lm' package for details

Value

a list of class 'mbal_oil' with all the required parameters for the mbal_perform_oil() S3 methods

Examples

```
p_pvt <- c(3330, 3150, 3000, 2850, 2700, 2550, 2400)

Bo <- c(1.2511, 1.2353, 1.2222, 1.2122, 1.2022, 1.1922, 1.1822)

Rs <- c(510, 477, 450, 425, 401, 375, 352)

Bg <- c(0.00087, 0.00092, 0.00096, 0.00101, 0.00107, 0.00113, 0.00120)

cw <- 2e-6

Bwi <- 1.0

Bw <- Bwi * exp(cw * (p_pvt[1] - p_pvt))

Rv <- rep(0, length(p_pvt))

muo <- rep(0.5, length(p_pvt))

muw <- rep(0.25, length(p_pvt))

mug <- rep(0.02, length(p_pvt))

pvt_table <- data.frame(p = p_pvt, Bo = Bo, Rs = Rs, Rv = Rv, Bg = Bg,
                       Bw = Bw, muo = muo, mug = mug, muw = muw)

p <- c(3330, 3150, 3000, 2850, 2700, 2550, 2400)

We <- rep(0, length.out = length(p))

Np <- c(0, 3.295, 5.903, 8.852, 11.503, 14.513, 17.730) * 1e6

Rp <- c(0, 1050, 1060, 1160, 1235, 1265, 1300)

Wp <- rep(0, length.out = length(p))

Wi <- rep(0, length.out = length(p))

Gi <- rep(0, length.out = length(p))

wf <- c(1, 1, 1, 0, 1, 0, 1)

mbal_optim_oil_lst <- mbal_optim_param_oil(input_unit = "Field",
output_unit = "Field", unknown_param = "N_m", aquifer_model = NULL,
phi = 0.2, swi = 0.2, Np = Np,Rp = Rp, Wp = Wp, Gi = Gi, Wi = Wi,
We = We, pb = 3330, p = p, pvt = pvt_table, cf = 0, wf = wf,
sorg = 0.2, sorw = 0)
```

```
dplyr::glimpse(mbal_optim_oil_lst)
```

`mbal_perform_gas` *Generic function for performance predictions for a gas reservoir*

Description

Generate a data frame of reservoir performance data according to the class of 'mbal_lst' and 'time_lst' objects

Usage

```
mbal_perform_gas(mbal_lst, time_lst)
```

Arguments

`mbal_lst`	a list object of class 'mbal_gas'
`time_lst`	a list object of class 'time/date'

Value

a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of the reservoir

References

Walsh MP, Lake LW (2003). *A Generalized Approach to Primary Hydrocarbon Recovery*, 1st edition. Elsevier Ltd. ISBN 9780444506832, https://www.elsevier.com/books/a-generalized-approach-to-primary-walsh/978-0-444-50683-2.

Walsh MP, Ansah J, Raghavan R (1994). "New, generalized material balance as an equation of a straight line: Part 1- Applications to undersaturated, volumetric reservoirs." *Proceedings of the Permian Basin Oil \& Gas Recovery Conference*, 549–564. doi: 10.2118/27684MS.

Walsh MP, Ansah J, Raghavan R (1994). "New, generalized material balance as an equation of a straight line: part 2- Applications to saturated and non-volumetric reservoirs." *Proceedings of the Permian Basin Oil \& Gas Recovery Conference*, 859–865. doi: 10.2118/27728MS.

Walsh MP (1995). "A Generalized Approach to Reservoir Material Balance Calculations." *Journal of Canadian Petroleum Technology*, **34**(01), 10. ISSN 0021-9487, doi: 10.2118/950107, https://doi.org/10.2118/95-01-07.

Fetkovich MJ, Reese DE, Whitson CH (1998). "Application of a General Material Balance for High-Pressure Gas Reservoirs (includes associated paper 51360)." *SPE Journal*, **3**(01), 3–13. ISSN 1086-055X, doi: 10.2118/22921PA, https://doi.org/10.2118/22921-PA.

Examples

```
p_pvt <- c(3700, 3650, 3400, 3100, 2800, 2500, 2200, 1900, 1600, 1300, 1000,
700,  600, 400)
Bo <- c(10.057, 2.417, 2.192, 1.916, 1.736, 1.617, 1.504, 1.416, 1.326, 1.268,
1.205, 1.149, 1.131, 1.093)

Rv <- c(84.11765, 84.11765, 70.5, 56.2, 46.5, 39.5, 33.8, 29.9, 27.3, 25.5, 25.9,
28.3, 29.8, 33.5) / 1e6

Rs <- c(11566, 2378, 2010, 1569, 1272, 1067, 873, 719, 565, 461, 349, 249, 218,
141)

Bg <- c(0.87, 0.88, 0.92, 0.99, 1.08, 1.20, 1.35, 1.56, 1.85, 2.28, 2.95, 4.09,
4.68, 6.53) / 1000

cw <- 3e-6

Bwi <- 10.05

Bw <- Bwi * exp(cw * (p_pvt[1] - p_pvt))

muo <- c(0.0612, 0.062, 0.1338, 0.1826, 0.2354, 0.3001, 0.3764, 0.4781, 0.6041,
0.7746, 1.0295, 1.358, 1.855, 2.500)

mug <- c(0.0612, 0.062, 0.0554, 0.0436, 0.0368, 0.0308, 0.0261, 0.0222, 0.0191,
0.0166, 0.0148, 0.0135, 0.0125, 0.0115)

muw <- rep(0.25, length(p_pvt))

pvt_table <- data.frame(p = p_pvt, Bo = Bo, Rs = Rs, Rv = Rv, Bg = Bg, Bw = Bw,
 muo = muo, mug = mug, muw = muw)

p <- c(3700, 3650, 3400, 3100, 2800, 2500, 2200, 1900, 1600, 1300, 1000, 700,
600)

We <- rep(0, length.out = length(p))

Np <- c(0, 28.6, 93, 231, 270, 379, 481, 517.2, 549, 580, 675, 755, 803) *1e3

Gp <- c(0, 0.34, 1.2, 3.3, 4.3, 6.6, 9.1, 10.5, 12, 12.8, 16.4, 19.1, 20.5) * 1e9

Wp <- rep(0, length.out = length(p))

Wi <- rep(0, length.out = length(p))

wf <- rep(1, length.out = length(p))

mbal_param_gas_lst <- mbal_perform_param_gas(input_unit = "Field",
output_unit = "Field", G = 2.41e10, aquifer_model = NULL,
phi = 0.1, swi = 0.2, Np = Np, Gp = Gp, Wp = Wp, Wi = Wi, We = We, pd = 3650,
p = p, pvt = pvt_table, M = 0, cf = 2e-6, wf = wf, sgrw = 0.15)
```

```
time_lst <- mbal_time(c(1:length(p)), "year")

mbal_results <- mbal_perform_gas(mbal_param_gas_lst, time_lst)

dplyr::glimpse(mbal_results)
```

---

mbal_perform_gas.volumetric_gas

S3 method for class 'mbal_perform_gas'

Description

Return a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of a volumetric gas reservoir

Usage

```
## S3 method for class 'volumetric_gas'
mbal_perform_gas(mbal_lst, time_lst)
```

Arguments

mbal_lst	a list object of class 'mbal_gas'
time_lst	a list object of class 'time'

Value

a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of a volumetric gas reservoir

---

mbal_perform_gas.water_drive_gas

S3 method for class 'mbal_perform_gas'

Description

Return a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of a water_drive gas reservoir

Usage

```
## S3 method for class 'water_drive_gas'
mbal_perform_gas(mbal_lst, time_lst)
```

Arguments

`mbal_lst`	a list object of class 'mbal_gas'
`time_lst`	a list object of class 'time'

Value

a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of a water_drive gas reservoir

---

mbal_perform_oil — *Generic function for performance predictions for an oil reservoir*

Description

Generate a data frame of reservoir performance data according to the class of 'mbal_lst' and 'time_lst' objects

Usage

```
mbal_perform_oil(mbal_lst, time_lst)
```

Arguments

`mbal_lst`	a list object of class 'mbal_oil'
`time_lst`	a list object of class 'time/date'

Value

a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of the reservoir

References

Walsh MP, Lake LW (2003). *A Generalized Approach to Primary Hydrocarbon Recovery*, 1st edition. Elsevier Ltd. ISBN 9780444506832, `https://www.elsevier.com/books/a-generalized-approach-to-primary-walsh/978-0-444-50683-2`.

Walsh MP, Ansah J, Raghavan R (1994). "New, generalized material balance as an equation of a straight line: Part 1- Applications to undersaturated, volumetric reservoirs." *Proceedings of the Permian Basin Oil \& Gas Recovery Conference*, 549–564. doi: 10.2118/27684MS.

Walsh MP, Ansah J, Raghavan R (1994). "New, generalized material balance as an equation of a straight line: part 2- Applications to saturated and non-volumetric reservoirs." *Proceedings of the Permian Basin Oil \& Gas Recovery Conference*, 859–865. doi: 10.2118/27728MS.

Walsh MP (1995). "A Generalized Approach to Reservoir Material Balance Calculations." *Journal of Canadian Petroleum Technology*, **34**(01), 10. ISSN 0021-9487, doi: 10.2118/950107, `https://doi.org/10.2118/95-01-07`.

Examples

```
p_pvt <- c(3330, 3150, 3000, 2850, 2700, 2550, 2400)

Bo <- c(1.2511, 1.2353, 1.2222, 1.2122, 1.2022, 1.1922, 1.1822)

Rs <- c(510, 477, 450, 425, 401, 375, 352)

Bg <- c(0.00087, 0.00092, 0.00096, 0.00101, 0.00107, 0.00113, 0.00120)

cw <- 2e-6

Bwi <- 1.0

Bw <- Bwi * exp(cw * (p_pvt[1] - p_pvt))

Rv <- rep(0, length(p_pvt))

muo <- rep(0.5, length(p_pvt))

muw <- rep(0.25, length(p_pvt))

mug <- rep(0.02, length(p_pvt))

pvt_table <- data.frame(p = p_pvt, Bo = Bo, Rs = Rs, Rv = Rv, Bg = Bg,
                       Bw = Bw, muo = muo, mug = mug, muw = muw)

p <- c(3330, 3150, 3000, 2850, 2700, 2550, 2400)

We <- rep(0, length.out = length(p))

Np <- c(0, 3.295, 5.903, 8.852, 11.503, 14.513, 17.730) * 1e6

Rp <- c(0, 1050, 1060, 1160, 1235, 1265, 1300)

Wp <- rep(0, length.out = length(p))

Wi <- rep(0, length.out = length(p))

Gi <- rep(0, length.out = length(p))

wf <- c(1, 1, 1, 0, 1, 0, 1)

mbal_param_oil_lst <- mbal_perform_param_oil(input_unit = "Field", output_unit = "Field",
aquifer_model = NULL, N = 1.37e8, m = 0.377, phi = 0.2, swi = 0.2, Np = Np,
Rp = Rp, Wp = Wp, Gi = Gi, Wi = Wi, We = We, pb = 3330, p = p, pvt = pvt_table,
cf = 0, wf = wf, sorg = 0.2, sorw = 0)

time_lst <- mbal_time(c(0, 365, 730, 1095, 1460, 1825, 2190), "day")

mbal_results <- mbal_perform_oil(mbal_param_oil_lst, time_lst)

dplyr::glimpse(mbal_results)
```

mbal_perform_oil.combination_oil
S3 method for class 'mbal_perform_oil'

Description

Return a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of a combination_drive oil reservoir

Usage

```
## S3 method for class 'combination_oil'
mbal_perform_oil(mbal_lst, time_lst)
```

Arguments

mbal_lst	a list object of class 'mbal_oil'
time_lst	a list object of class 'time'

Value

a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of a combination_drive oil reservoir

mbal_perform_oil.gas_cap_oil
S3 method for class 'mbal_perform_oil'

Description

Return a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of a gas_cap_drive oil reservoir

Usage

```
## S3 method for class 'gas_cap_oil'
mbal_perform_oil(mbal_lst, time_lst)
```

Arguments

mbal_lst	a list object of class 'mbal_oil'
time_lst	a list object of class 'time'

Value

a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of a gas_cap_drive oil reservoir

mbal_perform_oil.volumetric_oil

S3 method for class 'mbal_perform_oil'

Description

Return a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of a volumetric oil reservoir

Usage

```
## S3 method for class 'volumetric_oil'
mbal_perform_oil(mbal_lst, time_lst)
```

Arguments

mbal_lst	a list object of class 'mbal_oil'
time_lst	a list object of class 'time'

Value

a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of a volumetric oil reservoir

mbal_perform_oil.water_drive_oil

S3 method for class 'mbal_perform_oil'

Description

Return a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of a water_drive oil reservoir

Usage

```
## S3 method for class 'water_drive_oil'
mbal_perform_oil(mbal_lst, time_lst)
```

Arguments

mbal_lst	a list object of class 'mbal_oil'
time_lst	a list object of class 'time'

Value

a data frame with estimates for fluids saturation, drive indices, production rates, and gas-oil ratios over the pressure history of a water_drive oil reservoir mbal_perform_param_gas *A list object of class 'mbal_gas' for material balance analysis*

Description

Create an object of class 'mbal_gas'

Usage

```
mbal_perform_param_gas(
  input_unit = "Field",
  output_unit = "Field",
  aquifer_model = NULL,
  G = NULL,
  phi = NULL,
  swi = NULL,
  Gp = NULL,
  Np = NULL,
  Wp = NULL,
  Wi = NULL,
  We = NULL,
  pd = NULL,
  p = NULL,
  pvt = NULL,
  cf = NULL,
  M = NULL,
  phi_a = NULL,
  perm_h_a = NULL,
  perm_v_a = NULL,
  h_a = NULL,
  r_a = NULL,
  r_R = NULL,
  w_a = NULL,
  l_a = NULL,
  tetha = NULL,
  muw_a = NULL,
  cw_a = NULL,
  cf_a = NULL,
  wf = NULL,
  sgrw = NULL
)
```

Arguments

input_unit	a unit system for parameters, only the character string 'Field' is accepted
output_unit	a unit system for properties, only the character string 'Field' is accepted

aquifer_model	defaulted to NULL, otherwise must be a character string, one of the following eight options: 'uss_rad_edge', 'uss_rad_bottom', 'uss_lin_edge', 'uss_lin_bottom', 'pss_rad_edge', 'pss_lin_edge', 'pss_lin_bottom', 'pot'. For further information about each model, please see 'Raquifer' package reference manual (https://cran.r-project.org/web/packages/Raquifer/index.html)
G	original gas in place, SCF.
phi	reservoir porosity, a numeric fraction
swi	initial water saturation in the reservoir, a numeric fraction
Gp	cumulative gas production, SCF
Np	cumulative oil production, STB
Wp	cumulative water production, STB
Wi	cumulative water injection, STB
We	cumulative aquifer water influx, BBL. If unknown, a NULL value must be assigned
pd	dew point pressure, a numeric value, psi
p	reservoir pressure, a numeric vector, psi
pvt	a data frame of PVT properties including pressure 'p' in 'psi', oil formation volume factor 'Bo' in 'bbl/stb', solution gas-oil ratio 'Rs' in 'scf/stb', oil viscosity 'muo' in 'cp', volatilized oil-gas ratio 'Rv' in 'stb/scf', gas formation volume factor 'Bg' in 'bbl/scf', gas viscosity 'mug' in 'cp', water formation volume factor 'Bw' in 'bbl/stb', and water viscosity 'muw' in 'cp'
cf	formation compressibility, a numeric value or vector, 1/psi
M	ratio of non-net-pay pore volume to the reservoir (net-pay) volume, a numeric fraction.
phi_a	aquifer porosity, a numeric fraction
perm_h_a	aquifer horizontal permeability, md. Used in 'uss_rad_edge', 'uss_rad_bottom', 'uss_lin_edge', 'pss_rad_edge', 'pss_lin_edge' and 'pot' aquifer models
perm_v_a	vertical permeability, md. Used in 'uss_rad_bottom', 'uss_lin_bottom', 'pss_rad_bottom', and 'pss_lin_bottom' aquifer models
h_a	aquifer height, ft
r_a	aquifer radius, ft. Used in 'uss_rad_edge', 'uss_rad_bottom', 'pss_rad_edge', and 'pot' aquifer models
r_R	reservoir radius, ft. Used in 'uss_rad_edge', 'uss_rad_bottom', 'pss_rad_edge', and 'pot' aquifer models
w_a	aquifer width, ft. Used in 'uss_lin_edge', 'uss_lin_bottom', 'pss_lin_edge', and 'pss_lin_bottom' aquifer models
l_a	aquifer length, ft. Used in 'uss_lin_edge', 'uss_lin_bottom', 'pss_lin_edge', and 'pss_lin_bottom' aquifer models
tetha	fraction of reservoir encircled by the aquifer, degrees. Used in 'uss_rad_edge', 'pss_rad_edge', and 'pot' aquifer models
muw_a	aquifer water viscosity, cp

cw_a	aquifer water compressibility, a numeric value, 1/psi
cf_a	aquifer formation compressibility, a numeric value, 1/psi
wf	weight factor, a numeric vector of zeros and ones. A zero value excludes the entire row of reservoir history data at a particular time from the material balance analysis
sgrw	residual gas saturation in water invaded zone (aquifer encroachment or water injection), a numeric fraction

Value

a list of class 'mbal_gas' with all the required parameters for the mbal_perform_gas() S3 methods

Examples

```
p_pvt <- c(3700, 3650, 3400, 3100, 2800, 2500, 2200, 1900, 1600, 1300, 1000,
700,  600, 400)
Bo <- c(10.057, 2.417, 2.192, 1.916, 1.736, 1.617, 1.504, 1.416, 1.326, 1.268,
1.205, 1.149, 1.131, 1.093)

Rv <- c(84.11765, 84.11765, 70.5, 56.2, 46.5, 39.5, 33.8, 29.9, 27.3, 25.5, 25.9,
28.3, 29.8, 33.5) / 1e6

Rs <- c(11566, 2378, 2010, 1569, 1272, 1067, 873, 719, 565, 461, 349, 249, 218,
141)

Bg <- c(0.87, 0.88, 0.92, 0.99, 1.08, 1.20, 1.35, 1.56, 1.85, 2.28, 2.95, 4.09,
4.68, 6.53) / 1000

cw <- 3e-6

Bwi <- 10.05

Bw <- Bwi * exp(cw * (p_pvt[1] - p_pvt))

muo <- c(0.0612, 0.062, 0.1338, 0.1826, 0.2354, 0.3001, 0.3764, 0.4781, 0.6041,
0.7746, 1.0295, 1.358, 1.855, 2.500)

mug <- c(0.0612, 0.062, 0.0554, 0.0436, 0.0368, 0.0308, 0.0261, 0.0222, 0.0191,
0.0166, 0.0148, 0.0135, 0.0125, 0.0115)

muw <- rep(0.25, length(p_pvt))

pvt_table <- data.frame(p = p_pvt, Bo = Bo, Rs = Rs, Rv = Rv, Bg = Bg, Bw = Bw,
 muo = muo, mug = mug, muw = muw)

p <- c(3700, 3650, 3400, 3100, 2800, 2500, 2200, 1900, 1600, 1300, 1000, 700,
600)

We <- rep(0, length.out = length(p))

Np <- c(0, 28.6, 93, 231, 270, 379, 481, 517.2, 549, 580, 675, 755, 803) *1e3
```

```
Gp <- c(0, 0.34, 1.2, 3.3, 4.3, 6.6, 9.1, 10.5, 12, 12.8, 16.4, 19.1, 20.5) * 1e9

Wp <- rep(0, length.out = length(p))

Wi <- rep(0, length.out = length(p))

wf <- rep(1, length.out = length(p))

mbal_param_gas_lst <- mbal_perform_param_gas(input_unit = "Field",
output_unit = "Field", G = 2.41e10, aquifer_model = NULL,
phi = 0.1, swi = 0.2, Np = Np, Gp = Gp, Wp = Wp, Wi = Wi, We = We, pd = 3650,
p = p, pvt = pvt_table, M = 0, cf = 2e-6, wf = wf, sgrw = 0.15)

dplyr::glimpse(mbal_param_gas_lst)
```

---

mbal_perform_param_oil

A list object of class 'mbal_oil' for material balance analysis

---

Description

Create an object of class 'mbal_oil'

Usage

```
mbal_perform_param_oil(
  input_unit = "Field",
  output_unit = "Field",
  aquifer_model = NULL,
  N = NULL,
  m = NULL,
  phi = NULL,
  swi = NULL,
  Np = NULL,
  Rp = NULL,
  Wp = NULL,
  Gi = NULL,
  Wi = NULL,
  We = NULL,
  pb = NULL,
  p = NULL,
  pvt = NULL,
  cf = NULL,
  phi_a = NULL,
  perm_h_a = NULL,
  perm_v_a = NULL,
  h_a = NULL,
```

```
  r_a = NULL,
  r_R = NULL,
  w_a = NULL,
  l_a = NULL,
  tetha = NULL,
  muw_a = NULL,
  cw_a = NULL,
  cf_a = NULL,
  wf = NULL,
  sorg = NULL,
  sorw = NULL
)
```

Arguments

input_unit	a unit system for parameters, only the character string 'Field' is accepted
output_unit	a unit system for properties, only the character string 'Field' is accepted
aquifer_model	defaulted to NULL, otherwise must be a character string, one of the following eight options: 'uss_rad_edge', 'uss_rad_bottom', 'uss_lin_edge', 'uss_lin_bottom', 'pss_rad_edge', 'pss_lin_edge', 'pss_lin_bottom', 'pot'. For further information about each model, please see 'Raquifer' package reference manual (https://cran.r-project.org/web/packages/Raquifer/index.html)
N	original oil in place, STB
m	ratio of original gas cap volume to original oil leg volume, a numeric fraction
phi	reservoir porosity, a numeric fraction
swi	initial water saturation in the reservoir, a numeric fraction
Np	cumulative oil production, STB
Rp	ratio of cumulative produced gas to cumulative produced oil
Wp	cumulative water production, STB
Gi	cumulative gas injection, SCF
Wi	cumulative water injection, STB
We	cumulative aquifer water influx, BBL
pb	bubble point pressure, a numeric value, psi
p	reservoir pressure, a numeric vector, psi
pvt	a data frame of PVT properties including pressure 'p' in 'psi', oil formation volume factor 'Bo' in 'bbl/stb', solution gas-oil ratio 'Rs' in 'scf/stb', oil viscosity 'muo' in 'cp', volatilized oil-gas ratio 'Rv' in 'stb/scf', gas formation volume factor 'Bg' in 'bbl/scf', gas viscosity 'mug' in 'cp', water formation volume factor 'Bw' in 'bbl/stb', and water viscosity 'muw' in 'cp'
cf	formation compressibility, a numeric value or vector, 1/psi
phi_a	aquifer porosity, a numeric fraction
perm_h_a	aquifer horizontal permeability, md. Used in 'uss_rad_edge', 'uss_rad_bottom', 'uss_lin_edge', 'pss_rad_edge', 'pss_lin_edge' and 'pot' aquifer models

perm_v_a	vertical permeability, md. Used in 'uss_rad_bottom', 'uss_lin_bottom', 'pss_rad_bottom', and 'pss_lin_bottom' aquifer models
h_a	aquifer height, ft
r_a	aquifer radius, ft. Used in 'uss_rad_edge', 'uss_rad_bottom', 'pss_rad_edge', and 'pot' aquifer models
r_R	reservoir radius, ft. Used in 'uss_rad_edge', 'uss_rad_bottom', 'pss_rad_edge', and 'pot' aquifer models
w_a	aquifer width, ft. Used in 'uss_lin_edge', 'uss_lin_bottom', 'pss_lin_edge', and 'pss_lin_bottom' aquifer models
l_a	aquifer length, ft. Used in 'uss_lin_edge', 'uss_lin_bottom', 'pss_lin_edge', and 'pss_lin_bottom' aquifer models
tetha	fraction of reservoir encircled by the aquifer, degrees. Used in 'uss_rad_edge', 'pss_rad_edge', and 'pot' aquifer models
muw_a	aquifer water viscosity, cp
cw_a	aquifer water compressibility, a numeric value, 1/psi
cf_a	aquifer formation compressibility, a numeric value, 1/psi
wf	weight factor, a numeric vector of zeros and ones. A zero value excludes the entire row of reservoir history data at a particular time from the material balance analysis
sorg	residual oil saturation in gas invaded zone (gas cap expansion or gas injection), a numeric fraction
sorw	residual oil saturation in water invaded zone (aquifer encroachment or water injection), a numeric fraction

Value

a list of class 'mbal_oil' with all the required parameters for the mbal_perform_oil() S3 methods

Examples

```
p_pvt <- c(3330, 3150, 3000, 2850, 2700, 2550, 2400)

Bo <- c(1.2511, 1.2353, 1.2222, 1.2122, 1.2022, 1.1922, 1.1822)

Rs <- c(510, 477, 450, 425, 401, 375, 352)

Bg <- c(0.00087, 0.00092, 0.00096, 0.00101, 0.00107, 0.00113, 0.00120)

cw <- 2e-6

Bwi <- 1.0

Bw <- Bwi * exp(cw * (p_pvt[1] - p_pvt))

Rv <- rep(0, length(p_pvt))

muo <- rep(0.5, length(p_pvt))
```

```
muw <- rep(0.25, length(p_pvt))

mug <- rep(0.02, length(p_pvt))

pvt_table <- data.frame(p = p_pvt, Bo = Bo, Rs = Rs, Rv = Rv, Bg = Bg,
                       Bw = Bw, muo = muo, mug = mug, muw = muw)

p <- c(3330, 3150, 3000, 2850, 2700, 2550, 2400)

We <- rep(0, length.out = length(p))

Np <- c(0, 3.295, 5.903, 8.852, 11.503, 14.513, 17.730) * 1e6

Rp <- c(0, 1050, 1060, 1160, 1235, 1265, 1300)

Wp <- rep(0, length.out = length(p))

Wi <- rep(0, length.out = length(p))

Gi <- rep(0, length.out = length(p))

wf <- c(1, 1, 1, 0, 1, 0, 1)

mbal_param_oil_lst <- mbal_perform_param_oil(input_unit = "Field", output_unit = "Field",
aquifer_model = NULL, N = 1.37e8, m = 0.377, phi = 0.2, swi = 0.2, Np = Np,
Rp = Rp, Wp = Wp, Gi = Gi, Wi = Wi, We = We, pb = 3330, p = p, pvt = pvt_table,
cf = 0, wf = wf, sorg = 0.2, sorw = 0)

dplyr::glimpse(mbal_param_oil_lst)
```

---

mbal_time *A list object of class 'time' for material balance models*

Description

Create an object of class 'time'

Usage

```
mbal_time(x, unit = "day")
```

Arguments

x	a vector of times or a daily sequence of dates
unit	time/date unit of vector x

Value

a list of class 'time' with all the required parameters for the mbal_perform_oil(), mbal_perform_gas(), mbal_optim_oil(), mbal_optim_gas(), mbal_forecast_oil(), and mbal_forecast_gas() S3 methods

Examples

```
mbal_time_1 <- mbal_time(c(0:4) * 365, unit = "day")

mbal_time_1

mbal_time_2 <- mbal_time(c(0:4), unit = "month")

mbal_time_2

mbal_time_3 <- mbal_time(c(0:4), unit = "year")

mbal_time_3

mbal_time_4 <- mbal_time(seq(as.Date("2020/1/1"), by = "year",
length.out = 5), unit = "date")

mbal_time_4
```

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