ZetaAnalysis_Print.R

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```
# ==== DIFFERENTIAL EQUATION ====
ZETA.01 <- function(Time, State, Parm){

  #   # ---- EFFECTIVE STRESS PARAMETERS FOR CRUSHED SALT FORMULATION OF MODEL ----
  #   KAP0 <- 10.119
  #   KAP1 <- 1.005
  #   DDT  <- 0.896
  #   NK   <- 1.331
  #   KAP2 <- 1
  #   ETA0  <- 0.102854
  #   ETA1  <- 3.9387
  #   ETA2   <- 1
  #   NF    <- 3.5122

  # ---- EFFECTIVE STRESS PARAMETERS FOR CRUSHED SALT FORMULATION OF MODEL ----
  #   # ---- VALUES FOR MATHCAD CHECK
  KAP0 <- 10.119
  KAP1 <- 1.005
  NK   <- 1.331
  #--------------
  DDT  <- 0.8854
  KAP2 <- 1
  ETA0  <- 0.15
  ETA1  <- 1
  ETA2   <- 0.7
  NF    <- 8.40075

  #   # ---- Munson-Dawson Creep Parameters (17) ---- FOR CLEAN SALT
  #   A1    <- 8.386e22
  #   A2        <- 9.672e12
  #   Q1R   <- 12581
  #   Q2R   <- 5033
  #   N1        <- 5.5
  #   N2        <- 5.0
  #   B1        <- 6.0856e6
  #   B2        <- 3.034e-2
  #   Q         <- 5335
  #   S0        <- 20.57
  #   M         <- 3
  #   K0        <- 6.275e5
  #   C         <- 9.198e-3
  #   ALPHA <- -17.37
  #   BETA  <- -7.738
  #   DELTA <- 0.58
  #   MU        <- 12400

  # ---- Munson-Dawson Creep Parameters (17) ---- FOR ARGILLACEOUS SALT
  A1    <- 1.407e23
```

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A2        <- 1.314e13
Q1R   <- 12581
Q2R   <- 5033
N1        <- 5.5
N2        <- 5.0
B1        <- 8.988e6
B2        <- 4.289e-2
Q         <- 5335
S0        <- 20.57
M         <- 3
K0        <- 2.47e6
C         <- 9.198e-3
ALPHA <- -14.96
BETA  <- -7.738
DELTA <- 0.58
MU        <- 12400

#---- DATA INTERPRETED FROM TEST DATA
#   TEMP <- temp.interp(Time)
#   AS   <- as.interp(Time)
#   LS   <- ls.interp(Time)
#   D    <- d.interp(Time)

#---- constant data values for comparison to Callahan's analysis
TEMP <- 300
AS   <- (-6/300.9)*Time
LS   <- (-2/300.9)*Time
D    <- 0.9

# ---- calculate variables ----
# browser()
MS   <- (2.0 * LS + AS) / 3   # MEAN STRESS
DS    <- LS - AS                      # STRESS DIFFERENCE
DEN <- D                      # CURRENT FRACTIONAL DENSITY

Z3  <- State[1] # internal variable "zeta" for the transient function (FU)

VAR <- ifelse(DEN <= DDT, DDT, DEN)

# ---- Equivalent Stress ----
OMEGAA    <- ((1 - DEN) * NF / (1 - (1 - DEN)^(1/NF))^NF)^(2/(NF + 1))
ETA           <- ETA0 * OMEGAA^ETA1
TERMA    <- ((2 - DEN)/DEN)^((2 * NF)/(NF + 1))

# ---- Eqn. 2-3 (SAND97-2601) ----
# Equivalent stress measure for Disl. Creep
SEQF  <- sqrt(ETA * MS^2 + ETA2 * TERMA * DS^2)

# ==== START: equivalent inelastic strain rate form for dislocation creep ====
# ---- Steady State Strain Rate Calc ----
ES1 <- A1 * (SEQF / MU)^N1 * exp(-Q1R/TEMP)   # Dislocation climb - Eqn. 2-30
ES2 <- A2 * (SEQF / MU)^N2 * exp(-Q2R/TEMP)   # Undefined Mechanism - Eqn. 2-31
```

```r
  # Slip - Eqn. 2-32 (SAND98-2601)
  #   browser()
  ARG <- Q * ((SEQF - S0) / MU)
  ES3 <- (B1 * exp(-Q1R / TEMP) + B2 * exp(-Q2R / TEMP)) * sinh(ARG) * Heaviside(SEQF - S0)

  ESS = ES1 + ES2 + ES3 # Steady-state strain rate, Eqn. 2-29 (SAND97-2601)

  # ---- EVALUATE TRANSIENT FUNCTION, 3 branches: work hardening, equilibrium, recovery
  EFT  <- K0 * exp(C * TEMP) * (SEQF / MU) ^ M  # Transient Strain Limit, Eqn. 2-28
  BIGD <- ALPHA + BETA * log10(SEQF / MU)       # Work-Hardening parameter, Eqn 2-28

  FU <- ifelse(Z3 == EFT, 1, ifelse(Z3 < EFT, exp(BIGD * (1 - Z3 / EFT) ^ 2),
                                    exp(-DELTA * (1 - Z3 / EFT) ^ 2)))

  MD <- FU * ESS  # equivalent inelastic strain rate form for dislocation creep, Eqn 2-23

  DZ3 <- (FU - 1) * ESS  # derivative of internal variable "ZETA"
  DZ <- list(c(DZ3), MD, FU, ESS, ES1, ES2, ES3,
             DZ3, EFT, SEQF, BIGD, AS, LS)

  return(DZ)
}
```