Flowchart for iMagma © Viranga Perera & Alan P. Jackson Version: 4.95 start stop false true $\left(M_{\text{solidify}} \leftarrow f(V_{\text{Size}} \& \rho_{\text{m}})\right)$ false → CrustBuildOff → CrustBuildOn→ $\left(V_{\text{core}} \leftarrow f(\text{CMB})\right)$ $CMB < (R_{Moon} - d_f)$ $\left(E_{\text{solidify}} \leftarrow f(M_{\text{solidify}} \& H_f)\right)$ ¥ true $f_{core} = 1 - f_p$ $(f_{core} = 1)$ ₩ $\left(d_{cNonImp} += f(f_c, \rho_m, \rho_c, V_{Size}, R_{Moon}, A_{TotHoles})\right)$ false No holes? saturation? true 🗼 true↓ false $F_{dist} = 1$ $f_c = 1 - f_{core}$ $f_c = 1 - f_{core} - f_h$ d_m <- f(R_{Moon}, CMB, d_{cGlobal}) false \ $\left(L < -f(V_{MO}, V_{MOi})\right) \rightarrow T_{solidus} = \boxed{T_{solidus}} \rightarrow \left(\Delta T < -f(T_{CMB}, T_{solidus})\right) \rightarrow \left(T_{CMB} = T_{solidus}\right)$ \rightarrow $\left(T_{\text{topMO}} \leftarrow f(T_{\text{CMB}}, S_a, R_{\text{Moon}}, \text{CMB})\right)$ Ra = Ra $\left(d_{cNonImp} += d_{cExtra}\right)$ false QuenchOn QuenchOn & CrustBuildOn Accept t_{step} true $d_{cImp} = d_{hAvg}$ & Holes? false **√** false $\left(V_{\text{MO}} -= f(M_{\text{q}}, \rho_{\text{m}})\right)$ $\left(d_{cGlobal} = d_{cNonI}\right)$ $\left(d_{qGlobal} += f(d_{qNow}, d_{qGlobal})\right)$ **↓** true ¥ remove holes if false true remove holes if $d_h == d_{\text{cClobal}}$ $d_h == d_{\text{cClobal}}$ stop $M_q += f(d_{qNow}, d_{qGlobal}, A_{Moon}, A_{TotHoles}, \rho_q)$ $(d_q = d_{qMax})$ true CrustBuildOn true & ImpactsOn **√** true CrustBuildOff & QuenchOn true CrustBuildOn d_{qGlobal} != 0 & went thru all? true ImpactsOn $+= f(f_c, \rho_m, \rho_c, V_{Si})$ false went thru all? $\overset{\text{true}}{\rightarrow} \overset{\text{v}}{d}_{q} = \underbrace{Quench} \xrightarrow{} T_{Topq} = \underbrace{T_{surf}}$ es = Impacts -> false \leftarrow $(d_h += d_{cExtra})$ $(holeTracker \leftarrow$ $\left(E_{\text{toRelease}} += f(\lambda_{\text{KE}}, \text{KE}_{\text{imp}})\right)$ Ttrue false add KE_{imp}? CrustBuildOff $M_q += f(d_q, A_{holes}, \rho_q)$ $E_{\text{toRelease}} = E_{\text{solidify}} + E_{\text{cool}} - E_{\text{qForm}} + E_{\text{Extra}}$ ←E_{Extra} = General Heating \leftarrow $\left(E_{qForm} \leftarrow f(M_q, H_f)\right)$ $M_q += f(d_q, A_{hole})$ $\left(F_{\text{rad}} \leftarrow f(\epsilon, \sigma_{\text{SB}}, T_{\text{TopMO}}, T_{\text{e}})\right)$ QuenchOn & CrustBuildOff true 1 went thru all? false $\left(\overline{L_{rad} \leftarrow f(F_{rad}, A_{Moon})}\right)$ $d_{hq}/d_{hc}!=0$ false CrustBuildOn true false ImpactsOn $\left(t_{\text{toRelease}} < -f(E_{\text{toRelease}}, L_{\text{rad}})\right)$ false $L_{\text{holes}} += f(A_{\text{hole}}, \epsilon, \sigma_{\text{SB}}, T_{\text{TopMO}}, T_{\text{e}})$ $L_{Tot} = L_{holes} + L_{condRestMoon}$ $\left(L_{condRestMoon} < --f(A_{Moon}, A_{TotHoles}, c_{q/c}, \rho_{q/c}, \kappa_{q/c}, T_{melt} / T_{TopMO}, T_{Topq/c}, d_{q/cGlobal})\right)$ false true Accept stop TIMESTEP LOOP **FUNCTIONS** $M_{imp} \leftarrow f(last/N-body data, t_{ellapsed}/idx_{row}, t_{step})$ false KE_{imp} <- f(last/N-body data, t_{ellaps} t_{ellapsed} <= last data **↓** true $(A_{holes} \leftarrow f(k, M_{imp}))$ ►(Nu <- f(Ra)) $(idx_{rows} \leftarrow f(N-body data, t_{ellapsed}, t_{step})$ $(M_{imp} = 0)$ Return $\left(KE_{imp} = 0\right)$ false $d_q = d_{qMax}$ true $d_q > d_{qMax}$ false Return $(A_{holes} = o)$ $(idx_{row} \leftarrow f(idx_{rows}))$ General Heating $T_{\text{solidus}} < -f(CMB, L)$ false $\mathbf{E}_{\text{Extra}} = \mathbf{0}$ $\left(\text{Ra} \leftarrow f(a_g, \rho_m, \alpha_m, \Delta T, d_m, \eta_m, \kappa_m) \right)$ $T_{\text{surfhole}} = T_{\text{TopMe}}$ $F_{cond} \leftarrow f(\kappa_{lid}, \rho_{lid}, c_{lid}, T_{TopMO}, T_{TopLidGuess}, d_{lid})$ ₩ Return fT > tol true $\left(E_{\text{Extra}} \leftarrow f(h_{\text{rate}}, t_{\text{step}})\right)$ Return $T_{\text{surfhole}} = T_{\text{TopLidGue}}$ $\left(T_{\text{surfholeNew}} < -f(F_{\text{cond}}, \sigma_{\text{SB}}, \epsilon, T_{\text{e}})\right)$ \leftarrow $\left(T_{\text{surfhole}} = T_{\text{surfholeNew}}\right) \leftarrow \left(fT < -f(\%\text{error of } T_{\text{surfhole}} \& T_{\text{surfholeNew}})\right)$ Return **LEGEND** function condition calculation store array only for quench crust only for plag crust control sequence → loop