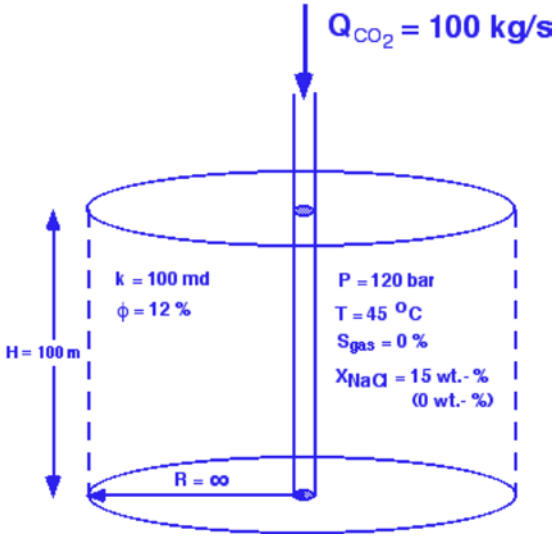
- When some mass components are not present in (parts of) the flow domain, or disappear in the course of a simulation, mass balances there reduce to "0=0".
- For example, TOUGH2/ECO2N and TOUGH2/ECO2M have components water, salt, CO2. Any of these may be absent or may disappear during the simulation in (parts of) the flow domain.
- This leads to poorly conditioned Jacobian matrices that have many zeros on the main diagonal, with adverse effects on convergence rates, time stepping, and execution times.

Example fragment from file LINEQ

```
AT KCYC=   24 AND ITER=    3, IZEROD=   30, ZPROCS = Z2 AND OPROCS = O3
    AT [  24,  3] DELT=0.327680E+05 IERR=0& ERR=7.830485E-09 IT=   27 ITC=      1033
AT KCYC=   24 AND ITER=    4, IZEROD=   20, ZPROCS = Z2 AND OPROCS = O3
    AT [  24,  4] DELT=0.327680E+05 IERR=0& ERR=5.956149E-09 IT=   32 ITC=      1065
AT KCYC=   25 AND ITER=    1, IZEROD=   30, ZPROCS = Z2 AND OPROCS = O3
    AT [  25,  1] DELT=0.327680E+05 IERR=0& ERR=5.814066E-09 IT=   30 ITC=      1095
    AT [  25,  2] DELT=0.327680E+05 IERR=0& ERR=9.751440E-09 IT=   29 ITC=      1124
    AT [  25,  3] DELT=0.327680E+05 IERR=0& ERR=7.587229E-09 IT=   24 ITC=      1148
    AT [  26,  1] DELT=0.655360E+05 IERR=0& ERR=2.316058E-09 IT=   39 ITC=      1187
AT KCYC=   26 AND ITER=    2, IZEROD=   40, ZPROCS = Z2 AND OPROCS = O3
    AT [  26,  2] DELT=0.655360E+05 IERR=0& ERR=6.444737E-09 IT=   41 ITC=      1228
    AT [  26,  3] DELT=0.655360E+05 IERR=0& ERR=8.181143E-09 IT=   34 ITC=      1262
    AT [  26,  4] DELT=0.655360E+05 IERR=0& ERR=8.874454E-09 IT=   34 ITC=      1296
AT KCYC=   26 AND ITER=    5, IZEROD=   31, ZPROCS = Z2 AND OPROCS = O3
```

Example (Jos Maas, TNO): TOUGH2/ECO2M simulation of CO2 injection into a 10-layer 2-D R-Z system (2-D version of the rcc3 sample problem).

- Initial conditions: aqueous-gas, with P = 20.e5 Pa, Xsm = 0.15, Saq = 0.1, T = 100 deg-C.
- Inject CO2 at T = 20 deg-C, at a rate of 10 kg/s per layer.
- When injecting pure CO2, aqueous phase will be removed by dissolution into the flowing CO2 stream, and water component will disappear in a region that expands outward from the injection well.
- Alternatively, co-inject water at a small rate, 1.e-6 kg/s per layer. Water solubility in CO2 is of order 1.e-3, so co-injecting water at a relative rate of 1.e-7 will have negligible impact on water dissolution in the CO2.
- Co-injection of water will avoid the "0=0" issues, and will allow better advance of the simulation.



	simulation times (s)	
time steps	pure CO2 injection	with co-injection of water
100	0.948096E+07	0.334735E+08
200	0.330489E+08	0.954056E+08
300	0.615995E+08	0.170221E+09
400	0.919015E+08	0.257621E+09
500	0.144961E+09	0.338490E+09