CLAIMS

1. A process for producing lithium metal from a lithium-containing silicate mineral, the process comprising:

mixing the silicate mineral with a nitric acid;

subjecting the mixture to a leaching process having conditions such that lithium values in the silicate mineral are leached from the silicate mineral as lithium nitrate;

decomposing the lithium nitrate to lithium oxide by a thermal treatment;

subjecting the lithium oxide to a carbothermal reduction stage in a carbothermal reduction furnace in which the lithium oxide is mixed with a source of carbon;

wherein the carbothermal reduction stage is operated at a temperature sufficient to cause the lithium oxide to be reduced to lithium metal and the carbon source to be oxidised into gaseous form.

2. A process according to claim 1, wherein, immediately following the reduction stage, the lithium metal as vapour and the gaseous oxidised carbon are rapidly cooled so as to form liquid lithium metal.

3. A process according to claim 2, wherein the lithium metal vapour and the gaseous oxidised carbon are rapidly cooled by expansion.

4. A process according to claim 2 or 3, wherein the lithium metal vapour and the gaseous oxidised carbon are rapidly cooled by supersonic expansion through a convergent-divergent nozzle.

5. A process according to any one of claims 2 to 4, wherein a mixture of the liquid lithium metal and the gaseous oxidised carbon is separated one from the other, such as by passing the mixture through a cyclone separator.

6. A process according to any one of the preceding claims, wherein, in the acid leach the silicate mineral is mixed with nitric acid under conditions such that lithium values in the silicate mineral are leached from the silicate mineral as lithium nitrate.

7. A process according to claim 6, wherein the leach conditions comprise increased temperature and/or pressure to accelerate leaching of lithium values from the silicate mineral as lithium nitrates, but such that non-lithium values in the silicate mineral tend not to be leached from the silicate mineral.

8. A process according to claim 7, wherein the leach conditions further comprise reacting the silicate mineral in a stoichiometric excess of nitric acid, for a controlled period of time, wherein the controlled period is terminated by:

(i) neutralising residual free nitric acid; and/or

(ii) heating the product of leaching so as to distil the excess of nitric acid along with water as vapour.

9. A process according to claim 8, wherein in (i) the residual free nitric acid is neutralised by an alkaline lithium compound that comprises one or more of: Li_2O, LiOH and Li_2CO_3.

10. A process according to claim 8 or 9, wherein in (ii) the excess of nitric acid and water vapour are distilled off as vapours in a drying stage, and wherein the distilled nitric acid and water vapour are collected for reuse in the acid leach and/or for regenerating nitric acid.

11. A process according to any one of claims 6 to 10, further comprising a crystallisation stage in which a solution of lithium nitrate produced by the acid leach is concentrated and crystallised to form crystalline $LiNO_3$.

12. A process according to claim 11, wherein the crystallised $LiNO_3$ is separated from solution, such as by centrifugation, and wherein the separated crystalline $LiNO_3$ is thermally treated, at a temperature that causes decomposition of the $LiNO_3$ into Li_2O, and such that a gaseous stream that comprises oxides of nitrogen is produced.

13. A process according to claim 12, wherein the thermal treatment comprises indirect heating of the $LiNO_3$, such as by the catalysed burning of ammonia in an excess of air, with the gaseous stream being collected for reuse in the acid leach and/or for regenerating nitric acid.

14. A system for producing lithium metal from a lithium-containing silicate mineral, the system comprising:

a leaching reactor in which a mixture of the silicate mineral and nitric acid is subjected to conditions such that lithium values in the silicate mineral are leached from the silicate mineral as lithium nitrate;

a thermal treatment unit configured to operate at a temperature that causes lithium nitrate from the leaching reactor to decompose into solid Li_2O;

a carbothermal reduction furnace in which a blend of the solid Li_2O and a source of carbon is heated to a temperature sufficient to cause the lithium oxide to be reduced to lithium metal and the carbon source to be oxidised into gaseous form.

15. A system according to claim 14, further comprising a flash-cooling apparatus in which the resultant lithium metal is condensed as a liquid.

16. A system according to claim 15, wherein the flash-cooling apparatus comprises a convergent-divergent nozzle.

17. A system according to claim 15 or 16, further comprising a cyclone separator in which the condensed liquid lithium metal from the flash-cooling apparatus and the gaseous oxidised carbon are separated.

18. A system according to any one of claims 14 to 17, wherein the thermal treatment unit comprises a roaster.

19. A system according to any one of claims 14 to 18, further comprising a nitric acid plant, the nitric acid plant arranged to receive gaseous streams that contain oxides of nitrogen and/or nitric acid vapour from the leaching reactor, the thermal treatment unit and/or from the carbothermal reduction furnace, the nitric acid plant being further arranged to produce nitric acid for use in the leaching reactor.

20. A system according to any one of claims 14 to 19, wherein the leaching reactor comprises:

a pressure vessel such as an autoclave in which leaching is conducted at elevated temperatures and pressures; or

a digestion reactor such as a hollow-flite screw conveyor in which leaching is conducted at elevated temperatures but at atmospheric pressure.

21. A system according to any one of claims 14 to 20, further comprising a crystallizer in which a lithium nitrate solution from the leaching reactor is concentrated and crystallised to form crystalline $LiNO_3$.

22. A system according to claim 21, further comprising a heated holding vessel in which the crystalline $LiNO_3$ is heated to a molten state, prior to the molten $LiNO_3$ being passed to the thermal treatment unit.