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KAOLINIZATION BY CIRCULATING SURFACE—WATER IN THE UPPER PART OF INTRUSIONS

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The author postulated in 1978 in the paper "Genesis and Age of Kaolin Deposits in Austria", that besides the normal weathering agents circulating ground water with variation in pH, redox potential resp. and mineralization is due for the building of clay minerals (kaolinite and montmorillonite).

H. SCHRÖCKE [1978] indicates in the publication "Geotektonik und Lagerstättenbildung", that one can explain hydrothermal reactions by a system of convection of ground water streams rising round the intrusives. The source of energy is the capacity of heat of the magma.

A hydrodynamic model [J. CATHLE and D. NORTON, 1974] — 2 km diameter of the pluton, top in 2.75 km depth — shows, that at a difference of temperature of

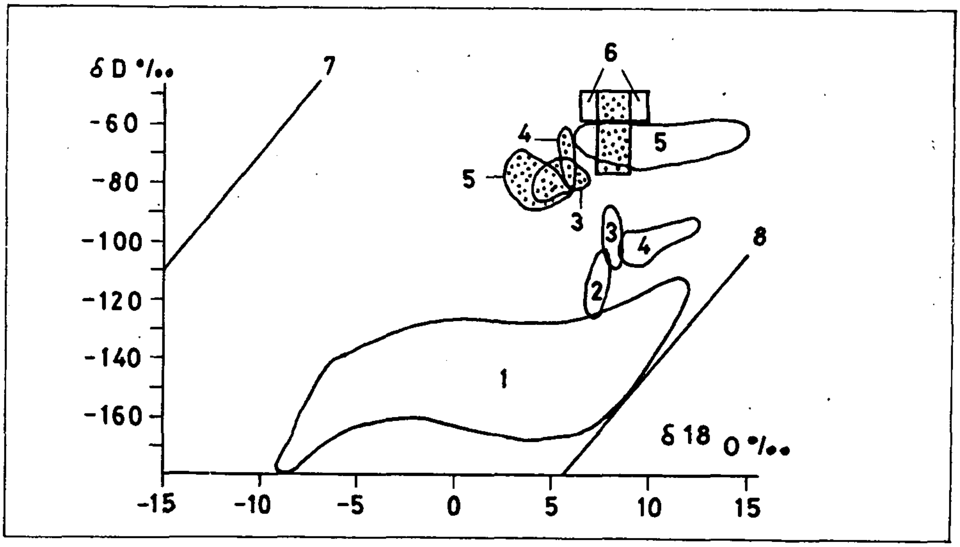

Fig. 1. O- and H-isotope ratios of clay minerals, biotite and sericite. SHEPPARD, NIELSON and TAYLOR [1971]
The isotope ratios of H and O of biotite, sericite (dotted) and clay minerals (white) from transformed rocks of the deposits Butte = 1, Climax = 2, Bingham = 3, Ely = 4, Santa Rita = 5. Hydrothermal water in equilibrium with biotites (calculated) of Bingham, Ely and Santa Rita = 6, area for magmatic water thick dotted. Composition for the surface water = 7, for O and H kaolinite in equilibrium with the surface water = 8.

700 °C against the neighbouring rocks convection streams of the pore water must be come about.

If the magmatic rocks have a permeability of 0,15 md (millidarcy) and the neighbouring rocks have a permeability of 0,30 md, in the time of cooling of the pluton in the range of 10^5 years until 20% of the starting temperature, there are 100 circulations.

The amount of water which goes through the upper part of the pluton is three times more than the mass running through the rock. The flow speed is about 30 m/year.

Hydrogen and oxigen isotope content of the layer-silicates of most of the porphyric copper ore deposits [S. SHEPPARD, 1969, 1971] lie in the D-^{18}O diagram between the streight line of the surface water and the streight line of the kaolin being in equilibrium. Sericite and clay minerals (kaolinite, montmorillonite) have D- and ^{18}O-values correspondig of today's rhythm of the surface water *(Fig. 1* and *2)*.

By intrusion into a sufficiently permeable neighbouring rock system a mechanism of convection starts, bringing cold surface water downwards *(Fig. 3)*.

As a result of cooling of the pluton or batholith follows the fissuring (thermal cracking). Depending on temperature, pH, Eh and the primary chemism of the parent

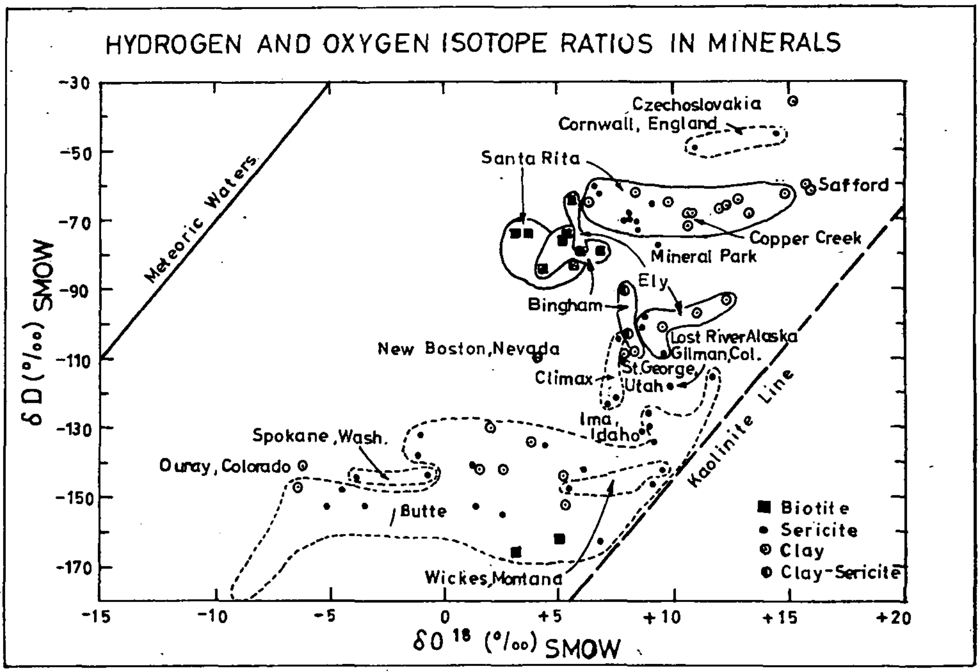

Fig. 2. O- and H-isotope ratios of clay minerals (several deposits, ČSSR and Cornwall). SHEPPARD, S. *et al.*, [1971]
Plot of D verus O^{18} for all the biotites and sericites analyzed in this study and for Butte by SHEPPARD and TAYLOR [1970]. Data for hypogene clays from porphyry copper deposits of the USA [SNT, 1969] and a dickite from Horni Slavkov, Czechoslovakia [SAVIN and EPSTEIN, 1970] are also included. The meteoric water line [CRAIG, 1961] and kaolinite line [SAVIN and EPSTEIN, 1970] are given for reference.

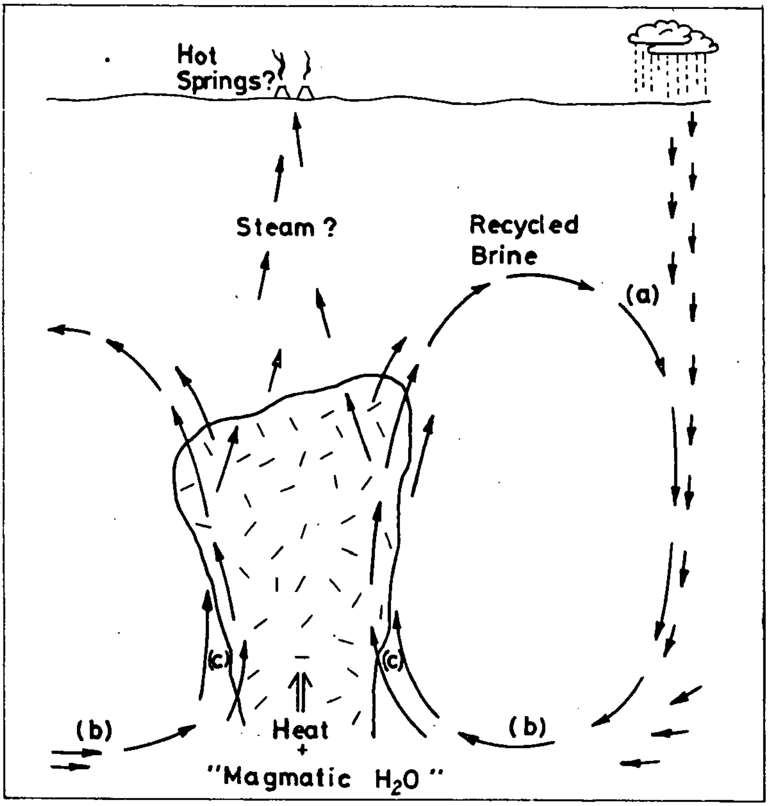

Fig. 3. Schematic cross-section of a porphyry copperstock, showing its postulated interaction and effect on groundwater circulation, in those situations where abundant argillic alteration has taken place. SHEPPARD, S. *et al.*, [1971]

rocks, kaolinite resp. other clay minerals are built by ascendent or descendent conditions. Mixed types are probably built, where surface water, magmatic water resp. pore water and reaction water (from OH of silicates) are participating.

SUMMARY

The formation of a deposit of kaolin is possible if following conditions are realized.

1. The rocks (granites, gneisses, granulites, porphyrites, trachytes, andesites etc.) must have the primary petrographic composition for building kaolinite, dickite, halloysite and other clay minerals.
2. It must be a tectonic or thermal fissuring to produce a sufficient permeability to allow a circulation of solutions.
3. These solutions must have a pH-value of ~ 7, a corresponding Eh-value, may or may not contain organic substances (?) and must have such a temperature, that in a certain time the reactions are going on to form a reasonable deposit of kaolin.

4. The kaolin must be protected by sedimentary overburden or by tectonical sinking. Now it is to be proved which possibility for the genesis of a deposit is actual.
   a) "Weathering" in the classical sense. Influence of organic material (humic and fulvic acids), bleaching and climatic factors.
   b) Convection of surface water and parts of magmatic water influenced by a "hot-spot" of a pluton.
   c) Hydrothermal origin in connection with volcanism.
   d) Mixed-type.

REMARK

The definition whether a deposit is of a weathering, a hydrothermal or of a mixed type depends on the low or high grade of investigation. So it is necessary to do more geological-mineralogical work and give more attention to the "tiny" minerals, which are mostly overlocked. Clay minerals are not so attractive as ore minerals. On the other hand we have to do more investigations in geochemical and isotope direction.

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