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CONDITIONS FOR DIRECT FORMATION OF GIBBSITE  
FROM K-FELDSPAR—DISCUSSION

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ABSTRACT

Two models for the *in situ* formation of gibbsite in the presence of quartz are discussed: one, based on slow percolation and localized weathering centers; the other on very rapid percolation and the shielding of quartz grains by their surface coatings.

Both conditions are present in the Pensauken formation, where authigenic gibbsite vermiforms were formed by alteration of feldspar, in the presence of abundant quartz sand.

The computations presented by Gardner (1970) for the equilibrium of kaolinite-quartz-gibbsite indicate that "gibbsite should not form as a result of kaolinite dissolution unless quartz is absent, the pH is above 4.2, and the initial concentration of dissolved silica is below  $10^{-4.6}$  moles per liter." This type of computation is useful, but it often does not agree with what we find in nature. In considering the environment for the formation of gibbsite the kaolinite-quartz-gibbsite system does not provide for the effect of feldspars and other aluminous silicates which may be present. In fact, gibbsite and quartz occur commonly together in laterites (deWeisse, 1964) and gibbsite often appears as pseudomorphs after feldspar (Deer, Howie, and Zussman, 1962).

That the presence of feldspar may radically affect the limits established by Gardner can be shown by the abundant presence of authigenic gibbsite vermiforms in the Pensauken formation of New Jersey (Lodding, 1961). These coarse sands and gravels of Pleistocene age are an arkosic deposit thought to be of fluvial origin (Bowman and Lodding, 1969). Quartz, orthoclase, and plagioclase are the major constituents of the Pensauken formation, but granite pebbles, in advanced stages of weathering, are occasionally found. Gibbsite vermiforms (up to 3 mm in length) and gibbsite cementing mineral grains are found in the non-glaucconitic members in many outcrops of the Pensauken. These vermiforms are delicately branched, contorted and rather fragile. Unlike the glauconite pellets which are reworked and probably of Cretaceous or Tertiary origin the gibbsite vermiforms are clearly

authigenic. Some were found adjacent to partly weathered feldspar grains, yet coarse and fine quartz sand is universally present. They are typically composed of 85–90 percent gibbsite, the remainder kaolinite, iron oxides, and a little quartz. Kaolinite vermiforms have been reported in several kaolin deposits (Carozzi, 1960), very similar in appearance to the gibbsite vermiforms in the Pensauken, but much smaller in size.

Two hypotheses may be considered: The Pensauken may be a case of arrested laterization. When feldspar particles weather in a sediment *at low percolation rates* and a warm climate, the alkalis are retained *locally*, around the feldspar grains with pH values which may be as high as 10 (Keller, 1958). In such a system, pH values may coexist, ranging locally from 2 to 10, depending on the mineral undergoing alteration. Thus, the decomposition of pyrite-marcasite may locally produce extremely low pH values and yet, a feldspar grain nearby could coexist in an alkaline environment. At a pH of 10, silica is highly unstable, making it possible for the sequence feldspar-kaolinite-gibbsite to go locally to completion. Therefore, feldspar alteration to gibbsite can take place with quartz grains surrounding, but not touching the decaying feldspar grain. Slow percolation removes the soluble alkali silicates, leaving aluminum hydroxides behind.

A second quite different alternative, based on the accepted model for lateritic weathering, is possible. Its thermodynamic aspects are discussed in an accompanying paper by Gardner (1971). Gibbsite vermiforms are found in the Pensauken in very coarse-grained, steeply crossbedded layers, showing excellent percolation. The quartz grains are coated with a layer of iron and manganese oxides, much thicker than ordinary surface stain. It is postulated that in such a system the  $p(\text{H}_4\text{SiO}_4)$  is kept low because the water is moving rapidly past these grains. Also access to the surface of the quartz grains proper is limited, since the iron-manganese oxide layer is quite impervious. No such surface layers form on the feldspar grains, and they are therefore exposed to the action of the rapidly percolating low-silica water, and to drying-wetting cycles,—certainly an environment conducive to gibbsite formation. This model takes in account both Gardner's requirement of a low-silica environment, and the apparent paradox of authigenic gibbsite surrounded by quartz grains.

Thus the mechanism depends on whether water percolates rapidly or slowly through these beds. Percolation rate is a function of the permeability of these sediments, which is high,—and that of the overlying materials,—which varies locally.

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CONDITIONS FOR DIRECT FORMATION OF GIBBSITE  
FROM K-FELDSPAR—FURTHER DISCUSSION

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## ABSTRACT

Theoretical analysis indicates that direct alteration of K-feldspar to gibbsite in the zone of weathering probably occurs only under conditions of good soil drainage and only if the pH is above 4.3. The analysis also indicates that gibbsite should not form if the soil water has an initial dissolved silica concentration above  $10^{-4.6}$  moles/liter. The calculations further show that, in the pH range 2 to 8, K-mica should not form as an initial precipitate in the hydrolysis of K-feldspar but must always be preceded by the precipitation of some kaolinite and/or gibbsite. This result may partly explain the rather infrequent occurrence of K-mica as a direct alteration product of K-feldspar.