Acta Mineralogica-Petrographica, Szeged, XXVII, 139—144, 1985

CRYPTOPSEUDOMORPHISM: A NEW PSEUDOMORPHIC TYPE

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ABSTRACT

A new pseudomorphic phenomenon, the so-called cryptopseudomorphism, is discussed here to the first time. This phenomenon is checked against the known types and found that it can not be paramorphic, replacement (substitution) or incrustation pseudomorphism. It is different as well from alteration pseudomorphism because: (1) The new pseudomorphic type is an occult or hidden phenomenon which can not be detected easily except by a combination of several techniques including x-ray diffraction, microscopic examination and chemical analysis. (2) While alteration pseudomorphism is the result of alteration of minerals at mild and more localized environment, the new pseudomorphic phenomenon requires more severe conditions like metamorphism or metasomatism acting on a more or less regional scale.

Three examples are given to illustrate this new phenomenon, the most important and most frequent of which is the albitization of basic oligoclase. Studying pseudomorphism of some uranium compounds revealed the presence of a special type called here radioactive pseudomorphism.

INTRODUCTION

The phenomenon of pseudomorphism of minerals is one which did not receive enough recent studies. However, this phenomenon is important in mineralogical studies as it allows to give an insight into mineral paragenesis and into chemical reactions involved in the formation of minerals. In this connection, DANA (1949) stated that: The chemical processes involved in such changes open a wide and important field for investigation. Their study has served to throw much light on the chemical constitution of mineral species and the conditions under which they have been formed.

The present work is essentially a contribution to the study of the phenomenon of pseudomorphism of minerals. It exposes a new type of pseudomorphism other than the well known four types, named by the authors cryptopseudomorphism. This new type so-called because it is not readily distinguished by the naked eye, rather it needs for its manifestation a combination of several methods including X-ray diffraction, optical study and chemical analysis, hence the prefix crypto-denoting a hidden or occult type of pseudomorphism. The term aphanopseudomorphism can alternatively be used as well on the basis that the Greek *aphanos* means unseen, but aphanite is a dense fine grained diabase with a compact texture. To avoid misuse and misunderstanding the term cryptopseudomorphism is more preferable.

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DEFINITION AND TYPES OF KNOWN PSEUDOMORPHS

The phenomenon of pseudomorphism has long been under study. Different authors defined the phenomenon in somewhat different ways. Thus, KRAUS *et al.* (1959) said that crystals alter in such a way that the external form of the original specimen is retained, such altered crystals are called pseudomorphous. DANA (1959) mentioned that if a crystal of a mineral is altered so that the internal structure is changed but the external form is preserved, it is called a pseudomorphous or false-form. The same author adds that the chemical composition and structure of a pseudomorph belong to one mineral species whereas the crystal outline corresponds to another.

MASON and BERRY (1967) defined pseudomorphism as follows: when a mineral can be replaced by another mineral without any change in the external form. BETEKHTIN (1968) discussed the phenomenon of pseudomorphism as replacement of crystal by a certain constituent in such a way that the resulting mineral retains not only the external shape but sometimes also the peculiar internal structure of the original mineral.

SINKANKAS (1969) defined the phenomenon as when a crystal changes chemically or structurally, yet keeps the shape of the original, it is called a pseudomorph, or false form, it looks like a crystal of one species but is composed of another. On the other hand READ (1973) states that pseudomorphism is the assumption by a mineral of a form other than that which really belongs to it.

It is clear that the previous authors agree that pseudomorphism implies both chemical and structural changes of a mineral species, while the external outline is kept unchanged.

Concerning the various types of pseudomorphs, most authors agree upon four main types despite the fact that they might classify them differently. KRAUS *et al.* (1959) referred to four types which are paramorphous, alteration, substitution and incrustation pseudomorphs. On the other hand, DANA (1959) recognised: substitution, incrustation, alteration and paramorphic pseudomorphism. MASON and BERRY (1967) mentioned that there are two types of pseudomorphism, one in which no change of substance occurs, the other in which there is addition of some element or elements and removal of others.

SINKANKAS (1969) claimed that there are two types of changes which are mainly chemical and structural. He adds as well the replacement type of pseudomorphism. READ (1973) tabulated the following four types of pseudomorphism: incrustation, infilteration, replacement (substitution) and alteration. This author mentioned that pseudomorphism may often be recognized by a want of sharpness in the edges of the crystals, whilst their surfaces usually present a dull and somewhat granular or earthy aspect.

DEFINITION OF THE NEW PSEUDOMORPHIC TYPE

A new pseudomorphic phenomenon is recorded here to the first time. In this type, the crystal has underwent chemical changes involving removal and addition of certain elements with the production of a new but closely related phase, at the same time the structural state of the new mineral is either modified or kept without change, the outer rims are still showing optical properties of the previous mineral. It should be emphasized once again that such mineral pseudomorph is occult and can not be recognised easily. As stated in the introduction, the authors propose the

name cryptopseudomorphism for this kind of pseudomorphs and suggest that it would be added as a fifth type to the previously mentioned list including four pseudomorphic types.

EXAMPLES ON THE NEW PSEUDOMORPHIC TYPE

Three examples are given here illustrating the new phenomenon of pseudomorphism, the so-called cryptopseudomorphism, they are partly taken from the first author's experimental work on feldspars and carbonates and partly taken from available literature.

1) The albitization of more basic plagioclase: EL SOKKARY (1970) reported the case of a plagioclase feldspar separated from Shaitian granite which is a special type of granitic rocks occurring in the south Eastern Desert of Egypt and found from optical determination and norm calculations that this plagioclase is basic oligoclase with 25% An, while the diffraction pattern identifies it as albite with not more than 10% An. This discrepancy between the two determinations of the plagioclase was attributed to a later albitization process of the more basic plagioclase.

EL SHAZLY, EL SOKKARY and KHALIL (1977) discussed in some detail the phenomenon of albitization of plagioclases. These authors stated that albitization of the more basic plagioclase can take place and results in the formation of albite and some other minor minerals. DICKINSON (1962) on studying the diagenesis of some andesites mentioned that the plagioclase was largely decomposed to albite plus one or more of several hydrous Ca-bearing minerals of which pumpellyite is the most abundant, although prehnite, laumontite and minor calcite also occur. SCHULZE and EL HINNAWY (1967) on studying the alteration of some basic sills and dykes pointed towards the albitization of plagioclase feldspars. They mentioned that KORSHINSKI (1963) indicated that the albitization of basic plagioclases could be regarded as a metamorphic process which took place at great depths.

EL SHAZLY *et al.* (1977) are inclined to the opinion that both albitization (and sericitization) of the feldspars of Shaitian granites are indications of a sort of Na and K-metasomatism accompanying metamorphism of the retrogressive type which occurred to these granites after their emplacement. It seems that the introduction of K in sericitization expelled Na which helped later in albitization of certain members of the same Shaitian rocks in a process of Na-autometasomatism.

Thus both KORSHINSKI (1963) and EL SHAZLY *et al.*, (1977) agree that the albitization of basic plagioclases is either a metamorphic process or a process of Na-metasomatism accompanying metamorphism.

DEER *et al.* (1972) mentioned that in matters of detail the structures of plagioclases are complex and vary according to chemical composition, conditions of crystallization and thermal history. As in the case of albite, so also for the whole plagioclase series, there are high-, low- and intermediate-temperature structural states.

Since the conversion of oligoclase to albite in the studied pseudomorphic type is essentially a chemical change from a feldspar with oligoclase composition (An_{10-30}) to a feldspar with albite composition (An_{0-10}), according to DEER *et al.* (1972) statement this should be accompanied by a structural change of the newly formed mineral. Moreover, the newly formed albite under metasomatic conditions is believed to be a high-temperature form when compared with the original low-oligoclase formed (together with the enclosing granite) under plutonic conditions of somewhat lower temperature of formation.

Thus in the studied pseudomorphic type, the formation of albite in place of oligoclase is accompanied by a structural change between the two mineral phases composing the pseudomorph.

2) Pseudomorphism of iron oxides and calcite after ferroan dolomite: EL SOKKARY (1981) studied the mineralogy and chemistry of a peculiar carbonate mineral occurring in a metamorphic zone at Wadi Um Kabu, South-Eastern Desert of Egypt. On the basis of X-ray diffraction and chemical analyses, this mineral proved to be a mixture of dolomite, hydrated ferric oxide mostly amorphous goethite, and calcite while its very coarse and brownish crystals give the impression that it is just only a dolomite mineral.

It seems that the original ferroan dolomite mineral started to break under metamorphic environment giving rise to minor colloidal goethite, calcite plus possible free magnesia phase, but still keeps the original ideal rhombohedral form.

It is argued that the present dolomite has acquired the structure of its predecessor: ferroan dolomite because the diffraction lines of the former do not accord precisely with those of dolomites of ASTM cards, rather they show certain limited displacements reflecting substitution in the unit cell, a matter which might reflect that the newly formed dolomite is pseudomorphous after ferroan dolomite.

It is worthy to note that EL SOKKARY (1977) mentioned that the schists of Wadi Um Kabu (the country rocks of the present carbonate mineral) were the place of certain chemical mobility under thermal metamorphic environment, the main elements that were mostly affected by differential mobilization in the present case are Ca, Fe and Mg. It is now possible to say that this type of pseudomorphism is the result of metamorphism.

3) Pseudomorphism of uranium compounds: GOLDSCHMIDT (1962, p. 564) mentioned that the composition of the pitchblende from certain veins corresponds more or less to that of U_3O_8, but gives X-ray interference diagrams of the fluorite lattice of UO_2.

KRAUSKOPF (1967) mentioned that the chief primary compound of uranium in vein deposits is the dioxide, UO_2, which occurs in the well crystallized variety uraninite and the microcrystalline form pitchblende. Incipient oxidation and loss of uranium by radioactive decay may increase the oxygen—uranium ratio, so that uraninite and pitchblende seldom show precisely the composition UO_2, often approaching a composition symbolized by U_3O_8.

Thus in the example given by GOLDSCHMIDT there is chemical change involving transformation of UO_2 to U_3O_8 but the original structure of UO_2 is retained. Here again is a peculiar type of pseudomorphs which deserves more study, but because radiation is the main initiating factor, it can be called radioactive pseudomorphism.

Despite that the processes responsible for chemical changes of the mentioned uranium compounds (incipient oxidation and loss of U by radioactive decay) are quite different from those responsible for chemical changes given in the previous two examples (metasomatism and/or metamorphism), yet pseudomorphs of uranium compounds, like the other two examples, are occult and could not be revealed except by chemical analysis combined with X-ray diffraction analysis.

DISCUSSION

On comparing the present type of pseudomorphs with the four known types, it can be said that the present pseudomorphic type can not belong to the paramorphic, the replacement (substitution) or incrustation types, the only known type which

may approach the present case is alteration pseudomorphism. DANA (1959) defined this kind of pseudomorphism as including a partial addition of new material or a partial removal of the original material, a case in which the unaltered mineral may be found in such pseudomorphous mineral. The common given examples are those of alteration of potash feldspars into kaolinite and the alteration of galena (PbS) to anglesite ($PbSO_4$). In the first example, there is removal of K and addition of H_2O, but the anionic silicate group is unchanged, while in the second example the cation (Pb) did not change and the anionic group has changed from S^{2-} to SO_4^{2-}.

In the new pseudomorphic case, there is both partial removal and addition of cations, while the anionic group remains unchanged, however the structural state of the new mineral has underwent in some cases a certain degree of change.

Nevertheless, the new type of pseudomorphism is different from alteration pseudomorphism, the most important differences are as follows. In the first place alteration pseudomorphism in all the given examples is a phenomenon which can be easily recognised by the naked eye *e.g.* kaolinization of feldspar but the new pseudomorph is an occult phenomenon which can not be easily detected except by a combination of several techniques including X-ray diffraction, microscopic examination and chemical analysis.

In the second place alteration pseudomorphism is the result of alteration of minerals occurring at mild and more localized environment, but the new type of pseudomorphism requires more severe conditions like metamorphism or metasomatism accompanying metamorphism acting on a more or less regional scale as seen from the example of albitization of basic oligoclase.

In the third place and in cryptopseudomorphism the newly formed mineral is closely related from a chemical point of view to the original mineral, this is again illustrated from albite pseudomorph after oligoclase.

On these grounds, the authors suggest that the present type of pseudomorphism is different from alteration pseudomorphism and deserves to be considered as a new type of pseudomorphs to be added to the other known types.

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Manuscript received, December 12, 1984