remains, and in all records to which the writer has access the pyrite-bearing beds are interstratified with glauconite-bearing beds, indicating that glauconite and pyrite are stable in the buried sediments (Fig. 1). Pyrite has not been observed in the outcrop area. In all, over 60 thin sections and 20 heavy mineral separations of Cretaceous and Tertiary sediments were studied, and in none of the specimens is pyrite present. Furthermore, S. N. Daviess (1946) noted pyrite in heavy mineral assemblages from well cores in this area but did not observe jarosite, thus it is reasonable to assume that jarosite does not exist in the deeply buried sediments.

Conclusion

The formation of the hydrous sulfate of potassium and ferric iron, jarosite, in Tertiary sediments along the west side of the San Joaquin Valley is a near-surface diagenetic process involving the reaction of sulfate-bearing interstratal solutions with glauconite. Efflorescent gypsum in the same strata very likely is formed coeval with jarosite by reaction of these solutions with calcium carbonate tests of microorganisms. There is reasonable assurance that the sulfate ions are released to the interstratal solutions by oxidation of pyrite, present in beds of the same formations beneath the San Joaquin Valley.

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FLUID INCLUSIONS IN BERYL AND QUARTZ FROM PEGMATITES OF THE MIDDLETOWN DISTRICT, CONNECTICUT

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During the past year and one-half, the writers have studied fluid inclusions in quartz and beryl from 9 pegmatites of the Middletown district, Connecticut (Cameron and Shainin, 1947), in an attempt to determine the role of temperature in the formation of the pegmatites. The visual method, by which inclusions are observed under the microscope during heating, has been used exclusively in the study. Each temperature

determination has been repeated at least once, as a precaution against leakage of the inclusions.

A number of sections of quartz from the Case pegmatites have been examined. Three types of fluid inclusions have been found in the mineral, as follows:

(1) Secondary inclusions situated along healed fracture planes. These are by far the most abundant type. The inclusions consist of a liquid phase plus a vapor phase that shrinks on heating and finally disappears. Four inclusions of this type in quartz from the Case No. 1 pegmatite gave temperatures of disappearance ranging from 316° C. to 343° C.

(2) Disseminated irregular inclusions. Most of these occur in the vicinity of healed fractures and are probably secondary. The type is divisible into two groups. One group consists of two-phase inclusions that behave like those of type (1) when heated. In 20 inclusions of this group in quartz from the core of the Case No. 2 pegmatite the vapor phase disappears at temperatures ranging from 199° C. to 292° C. The second group consists of inclusions in which first the vapor phase shrinks, then the liquid-vapor boundary fades and disappears. In 6 inclusions of this group in quartz from the core of the Case No. 2 pegmatite and in 1 inclusion in quartz from the wall zone, temperatures of boundary disappearance range from 320° C. to 390° C.

(3) Disseminated negative crystals, apparently primary. These contain a vapor phase and a liquid phase. When they are heated, first the vapor phase shrinks, then the liquid-vapor boundary fades and disappears. Temperatures of disappearance in 6 inclusions of this type from quartz of the core of the Case No. 2 pegmatite range from 293° C. to 347° C.

The number of inclusions for which data are given above is limited because most fluid inclusions in quartz fracture and leak before the temperatures of filling are reached.

Sections cut from specimens of quartz from the core of the Case No. 2 pegmatite, given by Cameron to Ingerson some years ago and studied by Ingerson (1947, p. 387) and Scott (1948, p. 650), were included in the study. Dr. Ingerson kindly returned the specimens for our use. He reported temperatures of disappearance of the vapor phase ranging from 153° C. to 165° C. Scott reported a value of 165° C. for a single specimen (46-C-3) run by the decrepitation method. We have been unable to duplicate the findings of these investigators. In a large number of sections of quartz cut from various specimens of the core, the only inclusions found that show disappearance of the vapor phase by shrinkage alone— type (1), and type (2) in part—are either definitely secondary or suspect of being secondary. Furthermore, temperatures of disappearance of the vapor phase range from 199° C. to 343° C. The significance of the temperature values obtained for the apparently primary inclusions of type (3) and for those of type (2) that behave similarly is uncertain.

More than 2,000 fluid inclusions in beryl crystals from the various

pegmatites have been studied, and temperatures of disappearance of vapor phase or of phase boundary in 441 fluid inclusions have been determined. We have had little trouble with leakage of inclusions in beryl during heating. Fluid inclusions in this mineral are of 4 principal types:

(1) Disseminated negative crystals with long axes parallel to the *c*-axis of beryl.
(2) Disseminated tubular inclusions with long axes parallel to the *c*-axis of beryl.
(3) Disseminated rounded, elongate, or irregular inclusions, unoriented with respect to crystallographic elements.
(4) Rounded, elongate, or irregular inclusions and negative crystals arranged along planes or curving surfaces of random orientation. Intersections of planes or surfaces are common.

Inclusions of types (1) and (2) are apparently primary. The origin of inclusions of type (3) is uncertain. Inclusions of type (4) are definitely secondary.

According to their behavior when heated, inclusions of types (1) and (2) are divisible into three groups, as follows:

Group A—Fluid inclusions having a vapor phase that shrinks on heating and finally disappears. Only beryl from the Selden east pegmatite contains inclusions of this group. The vapor phase disappears in various inclusions at temperatures ranging from 210° C. to 353° C.

Group B—Fluid inclusions in which the vapor phase expands on heating and finally occupies the entire cavity. Temperatures of disappearance of the liquid phase range from 305° C. to 401° C. Inclusions of this group occur in 4 of the pegmatites studied.

Group C—Fluid inclusions consisting of 3 phases (liquid-liquid-vapor) at room temperatures. At or somewhat below 31° C., one liquid phase disappears; this phase is probably liquid carbon dioxide. With further heating the vapor phase shrinks and finally disappears in turn, at temperatures ranging from 230° C. to 455° C. All inclusions of types (1) and (2) found in beryl crystals from the Case pegmatites are of this type. We are therefore unable to check the value of 175° C. determined by Ingerson (1947, p. 387) from a single inclusion in a beryl crystal from the Case No. 2 pegmatite.

The behavior of one inclusion of the negative crystal type in a crystal from the Bordonaro south pegmatite suggests that there may be additional group of inclusions in beryl. When this inclusion is heated, the vapor-liquid boundary remains unchanged in position but fades and finally disappears at 335° C. Four irregular inclusions arranged along a plane in a beryl crystal from the Case No. 1 pegmatite behave similarly. Temperatures of disappearance for these inclusions range from 311° C. to 316° C.

Curves obtained by plotting temperature against volume of liquid for the inclusions of group *A* correspond closely to calculated curves for hypothetical inclusions consisting of pure water. As the influence of composition on the vapor-liquid volume ratio cannot be predicted from available data, this correspondence does not prove that inclusions of

group *A* approach pure water in composition, but comparable curves for the inclusions of group *C* differ markedly from those for pure water. An attempt to determine molar concentrations by measuring freezing points of the liquid phases is being made.

The following conclusions are drawn from the results of the study to date:

(1) Quartz from the Case pegmatites is unsatisfactory for temperature studies by fluid inclusion methods. Most of the inclusions are secondary; others are suspect of being secondary. Inclusions that appear to be primary are few, and their significance in terms of temperatures of crystal formation is in doubt. The majority of the inclusions in quartz fracture and leak at temperatures below the true temperatures of cavity filling or disappearance of the liquid-vapor phase boundary. The source of the low values obtained by Scott by the decrepitation method is uncertain. The value may represent the temperature of bursting of the definitely secondary inclusions. If so, the inclusions must have burst at temperatures below the true temperatures of filling, as indeed would be expected from the present study. The same reasoning would hold if the values represent bursting of one or both types of disseminated inclusions. Correspondence between Dr. Ingerson and the writers has not as yet indicated a satisfactory explanation of the discrepancy between his results and ours. It may be, however, that the differences are related to the fact that the vapor bubbles are very difficult to see in the final stages of shrinkage. This caused difficulties in the early stages of the present investigation, but ultimately we found that satisfactory observations could be made and duplicated by different observers if the upper surfaces of the crystal plates studied were given a very high polish. Considerable adjustment of the illumination system was also necessary.

(2) Even if the pressure at time of crystal formation is known, temperatures at which the vapor phase disappears in fluid inclusions in beryl cannot be taken to indicate the temperatures of crystal formation until more is known of the compositions of the fluid inclusions. The behavior of the inclusions through a broad range of temperature must be determined as a clue to composition. Preliminary tests indicate that the lower limit of this range is well below 0° C.

(3) The use of fluid inclusions in pegmatite minerals for determining temperatures of formation requires full knowledge of the kinds of inclusions present and their behavior when heated. It seems apparent that decrepitation curves of these minerals cannot be interpreted satisfactorily on the basis of microscopic inspection of inclusions at room temperatures.

(4) The physical characteristics of fluid inclusions in quartz are difficult to determine because the inclusions are minute. In beryl crystals studied, all inclusions that appear to be primary consist of materials that are highly mobile at room temperatures and are evidently of low viscosity. This generalization holds for beryl from border zones and wall zones as well as for beryl from inner zones and replacement bodies. None of the cavities occupied by the inclusions contains solids. None shows linings that would indicate that material other than beryl has been precipitated on the walls during cooling of the inclusions since their formation. If the inclusions are primary and are true samples of the mother liquors from which beryl crystallized, then (1) the mother liquors had the physical characteristics of hydrothermal solutions, not magmas, and (2) the mother liquors of crystals formed in border zones did not contain all the constituents necessary for the quartz, feldspars, and micas

that formed subsequently in the inner zones of the pegmatites. A search for conclusive evidence of the origin of the inclusions is now needed, for if inclusions of types (1) and (2) are truly primary, and if current theory of the origin of fluid inclusions is valid, the pegmatites formed in open systems, not in closed or restricted (Cameron, Jahns, McNair, and Page, 1949, pp. 99–105) systems. We suggest, however, that even if the inclusions are ultimately proved to be primary, the assumptions underlying current theory of liquid inclusions should be reviewed, and they should be tested by laboratory studies of liquid inclusions in crystals precipitated from polycomponent solutions. Both the development and the composition of the inclusions should be investigated.

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APPARATUS FOR THE SEPARATION OF MINERAL GRAINS

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It is often necessary to separate a large number of microscopic mineral grains from an assemblage of various mineral grains. For example, if one desires a sample of a very pure mineral, it is often necessary to separate the pure mineral grain by grain from the gangue-locked grains. The usual method of picking individual grains with a stylus and tweezer is laborious and time-consuming, especially when a large number of grains is required. The apparatus to be described was constructed to facilitate and speed up the picking method.

For the most efficient use of a grain segregating apparatus, a concentrated sample of the desired mineral should be used. Thus, a rough purification of the mineral should be made in the conventional manner with an isodynamic separator, a superpanner, or heavy liquid separation. The mineral should then be screened as closely as possible. In this work 65 to 100 mesh was used.

The apparatus consists of three parts; namely, the distribution drum, the turntable and air ejector (see Fig. 1) and the vacuum picker (see