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FIRST KNOWN OCCURRENCE OF INYOITE IN A PLAYA, AT LAGUNA SALINAS, PERU[1]

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ABSTRACT

Inyoite ($Ca_2B_6O_{11} \cdot 13H_2O$) is here reported from near the surface of the borate playa, *Laguna Salinas*, Peru. The mineral occurs as crystal aggregates in a discontinuous bed up to 15 cm thick beneath a ulexite-bearing bed near the edge of the playa. The inyoite is the first established occurrence of a calcium borate in a playa. The mineral is primary at this place and was probably formed at about the same time as the enclosing muds.

The first known occurrence of the borate mineral, inyoite ($Ca_2B_6O_{11} \cdot 13H_2O$), in a playa is in the *Laguna Salinas*, Peru. The inyoite was probably formed at about the same time as the enclosing playa muds and is primary rather than being an alteration product of another borate.

*Laguna Salinas** is a borate playa, or *salar*, that lies at an altitude of about 14,000 feet, about 40 miles east of Arequipa, Peru. The playa occupies an enclosed basin that is underlain by young volcanic rocks of andesitic and dacitic composition (Jochamowitz, 1907). The black and olive-brown muds at the playa surface are covered during much of the year by an efflorescence, which according to Jochamowitz is composed of halite and thenardite. At depths of 5 to 15 cm. below much or all the playa surface there is a white volcanic ash bed as much as 15 cm. thick. The bed is probably part of the ash that was deposited during the explosive eruption of one of the neighboring volcanoes in 1600 and covers much of the surface of the Arequipa region (Jenks, 1948). Under the ash bed are layers of sandy black mud that contain nodules and irregular layers of ulexite ($NaCaB_5O_9 \cdot 8H_2O$), the common mineral of the South American borate playas. The ulexite layers range from a few centimeters to 2.5 m. in thickness. So far as I know, no other ulexite-bearing beds have been found at greater depth in the playa. The inyoite lies below the ulexite-bearing bed near one edge of the playa; elsewhere the ulexite beds are underlain by olive-brown mud.

The inyoite occurs predominantly as crystal aggregates in a discontinuous but compact layer up to 15 cm. thick near the eastern edge of the playa near the Tusca hot spring. Some of the inyoite also occurs as tiny clear pseudorhombs disseminated in the mud accompanying the bed of crystal aggregates. The bed has an extent of a few acreas and lies about a meter below the surface in structureless black mud; within the mud and above the inyoite bed are irregularly shaped and unevenly distributed

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* The following stratigraphic description of the playa is based on the detailed logs of regularly spaced exploration pits and on maps obtained by me from private sources.

lenses and masses of ulexite. The volcanic ash lies above, interspersed with black mud, and covered by efflorescent salts. No inyoite occurs along the extreme edge of the playa.

Figure 1 shows one of the inyoite crystal aggregates. They are clouded by inclusions of the mud in which they lie. The crystals are well-formed pseudorhombohedrons, intergrown in cockscomb-like fashion. The basal pinacoid (001) and the prism (110) are the dominant forms, modified in some crystals by small but perfectly developed pyramids (111). In form,

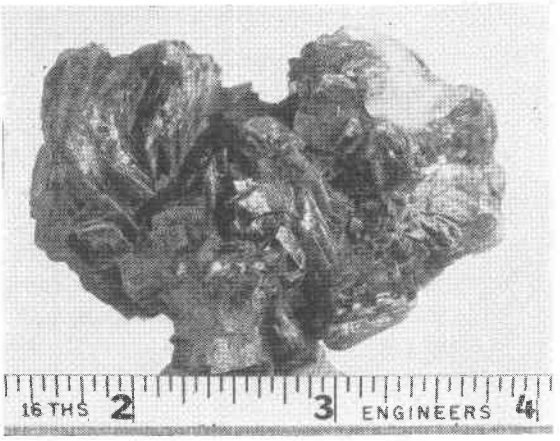

FIG. 1. Crystal aggregates of inyoite from Laguna Salinas, Peru.

the crystals are identical with those described by Schaller (1916) from the type locality in Death Valley. The indices of refraction (in white light), compared with those reported by Schaller, are:

	Peru	*California*
X	1.492±0.003	1.495
Y	1.505±0.003	1.51
Z	1.517±0.003	1.520
2V	Est. 70°–80°	70°
	Biaxial negative (−)	Biaxial negative (−)

Inyoite and ulexite have essentially the same indices of refraction; however, ulexite is biaxial positive (+) and has a distinctive fibrous habit.

The occurrence of inyoite is significant in two respects: (1) It is the only known occurrence of inyoite in a recent playa. Inyoite is the high hydrate of the colemanite series and it is therefore now known in an occurrence analogous to that of ulexite and borax, both the high hydrates of their respective mineral series. (2) This may be the first established occurrence of any calcium borate in a recent playa. Colemanite

($Ca_2B_6O_{11} \cdot 5H_2O$) has been reported from *Salar Cauchari*, Argentina, (Catalano, 1926) but more recent work in the same area by Ahlfeld and Angelelli (1948) and the writer suggests that the reported occurrence did not come from the *salar* but rather from the folded bedrock deposits in the same area. Foshag (1921), in a discussion of the physical and chemical conditions existing in playas, concluded that no calcium borates will form in them, as any calcium in solution will be fixed in the sodium-calcium borate, ulexite; the Peruvian occurrence of inyoite shows, however, that a calcium borate can form in playas, under surface or near-surface conditions of temperature and pressure.

The inyoite of the Salinas occurrence is primary, rather than being an alteration of an earlier borate mineral. This cannot be proved, of course, short of seeing the mineral actually growing in place. However, the facts that the inyoite has its own crystal habit rather than being pseudomorphous, and that so far no relicts of other borates have been recognized in the crystals convince me that the inyoite is the first-formed (primary) borate at this place. There seems no question that the crystals grew in the mud, and are therefore epigenetic if considered on a strict time scale, but on a grosser time scale the mud and the crystals formed at about the same time and in that sense can be considered syngenetic. That the inyoite is found only near a hot spring suggests that the constituents of the spring water were responsible at this place for the fixing of boron as inyoite rather than as ulexite. Moreover, if the ash bed is correctly dated, the inyoite could be very young.

The inyoite occurrence seems analogous to that of natron ($Na_2CO_3 \cdot 10H_2O$) in the alkaline lakes (wet playas) of British Columbia (Goudge, 1926). In these lakes natron occurs as surficial crusts and layers, which form during the winter and are called "winter crystal," and also as tiny euhedral crystals in the muds. According to Goudge the surficial natron dissolves in the spring, whereas the crystals do not. It seems obvious that the natron crystals in the mud are primary, as are the natron crusts, which form annually, and hence can almost be seen "actually growing in place."

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