The Zeolites of Queensland.

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The object of this paper is to give as complete a list as possible of the known Zeolites of Queensland together with the mode of occurrence of each, and its associated minerals. In addition a short account of the mode of formation of Zeolites in general is presented.

The peculiar properties of these minerals, particularly their continuous dehydration curves and capacity for base exchange, have attracted almost as much attention as their beauty and delicacy.

Zeolites, although hydrous minerals, are so often found filling cavities in igneous rocks that much interest in their origin has been aroused. The original theory, as stated in many works on mineralogy, is that they are secondary minerals derived by surface weathering and similar processes and owe their origin to the decomposition of minerals in the igneous rocks long after consolidation. A Harker (1904)[1] in "The Tertiary Igneous Rocks of Skye" introduced the radically different idea that Zeolites are products of the final phase of consolidation of the rocks and stated that the minerals produced by rock weathering differ from Zeolites in many important respects.

An intermediate position was taken by C. N. Fenner (1910)[2] for although he concluded that the vesicles of the Watchung Basalt were filled while it cooled, he thought the water concerned in the process was drawn not from the lava but from the underlying sediments.

J. J. Sederholm (1910)[3] introduced the term "deuteric" for "certain products occurring as an intergrowth of two minerals by reason of the action of magmatic end-stage emanations." R. J. Colony (1923) extended this term to cover not only the minute structures to which Sederholm referred but also to "all magmatic end-stage emanation phenomena, which frequently cause large scale changes and very profound effects, especially in the way of mineralisation."

J. L. Gillson, W. H. Callahan and W. B. Millar[4] in 1928 stated that the Adirondack gabbro was intruded by emanations or distillations of volatile constituents which rising from the chamber whence the gabbro came, produced "deuteric" minerals and afterwards pegmatites. F. F. Osborne[5] though he agreed with these facts thought the process was, nevertheless, secondary, not deuteric, and restricted the latter term to changes resulting from emanations derived by the crystallisation of the rock itself, and therefore produced in the rock towards the close of the period of crystallisation.

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[1] A. Harker (1904). "Tertiary Igneous Rocks of Skye," p. 41.

[2] C. N. Fenner (1910). Annals N.Y. Acad. Sci., Vol. 20, Pt. 2, pp. 95-187.

[3] J. J. Sederholm (1916). "On Synantetic Minerals and Related Phenomena." Bull. Geol. de Finlande, No. 48, p. 142.

[4] Gillson, J. L., Callahan, W. H., Millar, W. B. (1929). "Adirondack studies, the age of certain of the Adirondack gabbros and the origin of the reaction rims and peculiar border phases in them." Jour. of Geol., Vol. 36, pp. 149-163.

[5] F. F. Osborne (1929). Econ. Geol., Vol. 24, p. 335.

Sederholm[6] in 1929 redefined the term "deuteric" saying that his original purpose was "to make it possible to discriminate between such metasomatic changes as belong to a later period of metamorphism, *i.e.*, are secondary in the strictest sense of the word, and those that have taken place in direct continuation of the consolidation of the magma of the rock itself." The term was not meant to be descriptive of the process, but to denote changes in the minerals caused by the process. He thought it difficult to decide whether the solutions had emanated from the nearest portions of the rock masses undergoing crystallisation or from the magma still remaining liquid at depth, but he was inclined to lay more stress upon the first of these processes.

Inasmuch as many writers have now accepted this view that Zeolites are formed as final stages of consolidation and not as the first stages of destruction, they are now usually regarded as deuteric minerals.

Judging from the interest taken in these minerals overseas, it is rather remarkable that they have escaped attention for so long in Queensland. One of the first accounts of them is E. B. Lindon's paper, "A Catalogue of such minerals as are at present known in Queensland, with their principal associations and places of occurrence," published in 1887. In this Lindon records eight Queensland Zeolites known at the time.

R. L. Jack, with his usual keen powers of observation, noted several occurrences which are scattered through his reports.

In "The Queensland Mineral Index" Zeolites are recorded and all known localities are noted. This was published in 1913. From then until 1926 it is of interest to note that no Zeolites are mentioned in the reports of the Geological Survey.

QUEENSLAND ZEOLITES.

A brief account of the known Zeolites of Queensland with their localities is set out below. Those marked with an * indicate hitherto unrecorded specimens.

1. ANALCITE. Chem. Comp. Na Al $(SiO_3)_2 + H_2O$.
   Crystalline form: Isometric. Sp. Gr. 2.22-2.29.

   A. In cavities and amygdules in altered igneous rocks associated with Prehnite, Thomsonite and Laumontite.
      Loc. Bowen River about 50 to 60 miles S.S.W. of Bowen; at Pelican Creek a branch of the Bowen River, and at Strathmore Creek.
      Ref. "Report on the Bowen River Coalfield," by R. L. Jack. Geol. Surv. Qld. Pub. 4, 1879, p. 6.
      See 7A and 12A.

   B. In basalt.
      Loc. Peak Downs Goldfield, Clermont.
      Ref. "Handbook of Queensland Geology," by R. L. Jack, 1886.

   C. Associated with Natrolite and Calcite.
      Loc. Morinish Goldfield, 29 miles N.W. of Rockhampton.
      Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld. Pub. 241, 1913.
      See 8K.

[6] J. J. Sederholm (1929). Econ. Geol., Vol. 24, p. 869.

D. In decomposed basalt.

Loc. Fitzroy River, Rockhampton.

Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld. Pub. 241, 1913.

2. APOPHYLLITE. Chem. Comp. $H_7K\ Ca_4\ (SiO_3)\ O_8 + H_2O$.
Crystalline form: Tetragonal. Sp. Gr. 2.2-2.4.
(Although not a true Zeolite this mineral is so closely related that it is included in this report.)

A. In basalt.

Loc. Evelyn Run, 11 miles S. of Herberton.

Ref. "List of Minerals, Walsh and Tinaroo Mining District, North Queensland," by J. Stewart Berge, J. Harrison Brownlea, R. Colin Ringrose. Proc. Roy. Soc. Qld., vol. 15, 1900, p. 61.

B. In basalt.

Loc. Jump-Up Mine, Herberton road, 9 miles S.S.W. of Alberton Rail Station. Walsh and Tinaroo Mineral Fields.

Ref. "List of Minerals, Walsh and Tinaroo Mining District, North Queensland," by J. Stewart Berge, J. Harrison Brownlea, R. Colin Ringrose. Proc. Roy. Soc. Qld., vol. 15, 1900, p. 61.

C. In vein of Quartz in granite country.

Loc. Hidden Treasure Mine, East side of Mundic Creek, 24 miles S.S.W. of Rockhampton.

Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913.

3. CHABAZITE. Chem. Comp. $(Ca.\ Na_2)\ Al_2\ Si_4\ O_{12} + 6H_2O$.
Crystalline form: Rhombohedral. Sp. Gr. 2·08-2·16.

A. In basalt, Peak Downs Goldfield, Clermont.

Ref. "Handbook of Queensland Geology," by R. L. Jack, 1886.

B. In basalt, associated with Stilbite. Found by A. C. Gregory.
Loc. Toowoomba.

Ref. "Catalogue of Minerals exhibited in the Qld. Court Colonial and Indian Exhibition of 1886," p. 131.

See 11A.

C. In decomposed basalt, Freestone Creek, north of Warwick.

Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913.

Note: Specimen in Queensland Museum labelled "Chabazite Loc. Darling Downs" may also refer to this specimen.

*D. In cavities in basalt associated with Natrolite, Calcite, and Quartz.

Loc. Round Mountain, 12 miles S. of Beaudesert.

See 8N.

3. Chabazite (var. Phacolite).

E. Associated with Calcite, Ferro-calcite and Natrolite in basic volcanic tuff.

Loc. Railway cutting between Spring Bluff and Harlaxton Railway Station, 5 miles north of Toowoomba.

Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913. See 8E.

F. Associated with Calcite, Magnesite, and Natrolite in decomposed basalt.

Loc. Mt. Davidson, 5 miles S.S.E. of Toowoomba.

Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913.

See 8H.

4. Gismondite. Chem. Comp. $Ca.Al_2\ (SiO_3)_4 + 4H_2O$(?).
Crystalline form: Monoclinic. Sp. Gr. 2.265.

A. In basalt, Rosewood Goldfield, 32 miles N.W. of Rockhampton. Recorded from specimen in Queensland Museum.

Ref. E. B. Lindon "Catalogue of such minerals as are at present in Queensland, with their principal associations and places of occurrence." Proc. Roy. Soc. Qld., vol. 4, 1887, p. 68.

B. In vughs in "granite" associated with Laumontite, Prehnite, Calcite, Chlorite, and Pyrite.

Loc. Enoggera.

Ref. "The Deuteric Mineral Sequence at Enoggera, Queensland," by M. J. Whitehouse. Min. Mag., vol. XXIV., No. 157, June, 1937.

See 7G.

5. Harmotome. Chem. Comp. $H_2(K_2\ Ba)\ Al_2\ Si_5\ O_{15}$.
Crystalline form: Monoclinic. Sp. Gr. 2.44-2.50.

A. Muldiva Mines, 7 miles W.S.W. of Almaden Railway Station (Chillagoe Line). Walsh and Tinaroo Mineral Field.

Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld, Pub. 241, 1913.

6. Heulandite.. Chem. Comp. $H_4\ Ca\ Al_2\ Si_6\ O_{18} + 3H_2O$.
Crystalline form: Monoclinic. Sp. Gr. 2-18-2.22.

A. Associated with Calcite and Quartz.

Loc. Plant's Shaft, Golden Gate Gold Mines, Golden Gate Reef, 4 miles N.W. of Croydon Railway Station, Croydon Gold Field.

Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld. Pub. 241, 1913.

B. As a lining in geodes in granite.

Loc. Enoggera.

Ref. Geol. Surv. Museum.

(This Zeolite is not Heulandite but Laumontite q.v.)[1]

[1] See "Deuteric Mineral Sequence at Enoggera, Queensland," by M. J. Whitehouse. Min. Mag., Vol. XXIV., No. 157, June, 1937.

*C. With Natrolite on melophyre.
Loc. Agricultural Reserve, Rockhampton, Qld.
Ref. Queensland Museum.
See 8o.

D. (or Stilbite) In Quartz veins.
Loc. Plant's Shaft, Golden Gate Reef, 4 miles N.W. of Croydon Railway Station.
Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913.
See 11D.

7. LAUMONTITE. Chem. Comp. H_4 Ca Al_2 Si_4 $O_{14} + 2H_2O$.
Crystalline form: Monoclinic. Sp. Gr. 2.25-2.36.

A. In cavities and amygdules in altered igneous rocks associated with Prehnite, Thomsonite, and Analcite.
Loc. Bowen River, about 50-60 miles S.S.W. of Bowen, at Pelican Creek, a branch of the Bowen River, and at Strathmore Creek.
Ref. "Report on Bowen River Goldfield," by R. L. Jack. Geol. Surv. Qld. Pub. 4, 1879, p. 6.
See 1A and 12A.

B. Associated with Calcite, Chalcedony, and Agate in basic rock.
Loc. Nr. McGregor, 2½ miles N.E. of Mt. Toby, 2½ miles N.N.E. of Mirani Railway Station (Mackay Line).
Ref. "Report on Geological Features of Hazledean with notes on the Coal, Limestone, and other Mineral Products of the Mackay District." Geol. Surv. Qld., Pub. 164, 1901.

C. In altered igneous rocks.
Loc. Bowen River, about 50 miles S.W. of Bowen.
Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913.

D. Associated with Quartz, Calcite, and Stilbite, in andesite.
Loc. Cracow.
A chemical analysis of this mineral is:—

	Per cent.
Water	14·2
SiO_2	50·5
Al_2O_3	22·4
CaO	12·5
Soda (by Dif.)	0·4

Ref. "The Cracow Goldfield," by A. K. Denmead. Qld. Govt. Mining Jour., September, 1932, p. 374.
See 11E.

E. As veinlets or lining joint planes associated with Calcite, Chlorite, Pyrite, and Stilbite in the andesitic lode material.
Loc. Mt. Coolon.
Ref. "Mount Coolon Goldfield," by C. C. Morton. Qld. Govt. Min. Jour., June, 1930, p. 199.
See 11H.

F. As a lining in geodes in granite.
Loc. Enoggera.
Ref. Geol. Surv. Museum.

G. In veins and vughs associated with Prehnite, Gismondite, Calcite, Chlorite, Epidote, Tourmaline, Fluorite, Sphalerite, Molybdenite, and Kaolin in "granite."
Loc. Enoggera.
An analysis of this is—

	Per cent.
SiO_2	52·13
Al_2O_3	23·04
Fe_2O_3	0·20
CaO	11·85
MgO	trace
Na_2O	0·14
H_2O	12·64

Ref. "Deuteric Mineral Sequence at Enoggera, Queensland," by M. J. Whitehouse. Min. Mag., Vol. XXIV., No. 157, June, 1937.
See 4B.

8. NATROLITE. Chem. Comp. $Na_2\ Al_2\ Si_3\ O_{10} + 2H_2O$.
Crystaline form: Orthorhombic. Sp. Gr. 2.20-2.25.

A. In basalt, Peak Downs Goldfield, Clermont.
Ref. "Handbook of Queensland Geology," by R. L. Jack, 1886.

B. In basalt.
Loc. Toowoomba and near Ipswich.
Ref. "Catalogue of such minerals as are at present known in Queensland with their principal associations and places of occurrence," by E. B. Lindon. Proc. Roy. Soc. Qld., vol. 4, 1887, p. 67.

C. At Muldiva, 7 miles W.S.W. of Almaden Railway Station (Chillagoe line). Walsh and Tinaroo Mining Fields.
Ref. "List of Minerals, Walsh and Tinaroo Mining District, N. Qld.," by J. Stewart Berge, J. Harrison Brownlea, and R. Colin Ringrose. Proc. Roy. Soc. Qld., Vol. 15, 1900, p. 61.

D. In basalt.
Loc. Deep Lead, Herberton, 12 miles S.S.W. of Atherton Railway Station. Walsh and Tinaroo Mining Fields.
Ref. "List of Minerals, Walsh and Tinaroo Mining District, N. Qld," by J. Stewart Berge, J. Harrison Brownlea, and R. Colin Ringrose. Proc. Roy. Soc. Qld., Vol. 15, 1900, p. 61.

E. Associated with Chabazite (var. Phacolite), Calcite, and Ferrocalcite in basic volcanic tuff.
Loc. Railway cutting between Springbluff and Harlaxton Railway Stations, 5 miles N. of Toowoomba.
Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913.
See 3E.

F. In decomposed basalt.
Loc. Rosella Creek, Havilah, Bowen River.
Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913.

G. Loc. Boonah, 55 miles S.S.W. of Brisbane.
Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913.

H. Associated with Calcite, Chabazite, and Magnesite in decomposed basalt.
Loc. Mt. Davidson, 5 miles E.S.E. of Toowoomba.
Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913.
See 3F.

J. In vesicular basalt. Collected by L. C. Ball.
Loc. "The Falls," Mapleton, about 7 miles S.W. of Nambour Railway Station.
Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913.

K. Associated with Analcite and Calcite.
Loc. Morinish Goldfield, 29 miles N.W. of Rockhampton.
Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913.
See 1C.

*L. Loc. Minden, Rosewood District.
Ref. Geol. Surv. Museum.

*M. Associated with Chalcedony in basalt.
Loc. Ravenswood.
Ref. Qld. Museum, Reference Collection.

*N. In cavities in basalt associated with Chabazite, Calcite, and Quartz.
Loc. Round Mountain, Beaudesert District.
See 3D.

*O. With Heulandite on melaphyre.
Loc. Agricultural Reserve, Rockhampton.
Ref. Queensland Museum.
See 6C.

9. SCOLECITE. Chem. Comp. $Ca(AlOH)_2 (SiO_3)_3 + 2H_2O$.
Crystalline form: Monoclinic. Sp. Gr. 2.16-2.4.

A. Magnet Copper Mine, Cloncurry Field.
Ref. Geol. Surv. Museum.

B. Associated with Calcite in granite.
Loc. Mary Mine, Charters Towers Goldfield.

Analysis:—	Per cent.
SiO_2	49·04
Al_2O_3	26·64
CaO	12·24
H_2O (by ignition)	13·30
Fe_2O_3	trace

Ref. "On the Mineral Scolecite occurring on Granite, Charters Towers," by A. W. Clarke. Proc. Roy. Soc. Qld., Vol. 4, 1887, p. 110.

C. Associated with Calcite in granite.
Loc. Mexican Mine, Charters Towers Goldfield.

Analysis:—

	Per cent.
SiO_2	47·24
Al_2O_3	26·64
CaO	12·95
H_2O	14·20
Fe_2O_3	trace

Ref. "On the Mineral Scolecite occurring on Granite, Charters Towers," by A. W. Clarke. Proc. Roy. Soc. Qld., Vol. 4, 1887, p. 110.

D. Associated with Calcite in granite.
Loc. Queen Block Extd. Mine, Charters Towers Goldfield.

Analysis:—

	Per cent.
SiO_2	46·25
Al_2O_3	27·35
CaO	13·95
H_2O	13·47
Fe_2O_3	traces

Ref. "On the Mineral Scolecite occurring on Granite, Charters Towers," by A. W. Clarke. Proc. Roy. Soc. Qld., Vol. 4, 1887, p. 110.

(*Note.*—In the same year the above report was published, E. B. Lindon wrote: "A Note on a paper entitled 'On the Mineral Scolecite occurring on Granite, Charters Towers,' in which he questioned whether the mineral was really Scolecite and suggested Laumontite for it.

Clarke replied that on comparing chemical analyses it was nearer to Scolecite.)

10. Sloanite. Chem. Comp. Hydrated aluminous silicate of lime and magnesium.
Crystalline form: Orthorhombic. Sp. Gr. 2.441.

A. Indentified from basalt of Darling Downs.
Ref. "Catalogue of Minerals exhibited at Queensland Court, Colonial and Indian Exhibition, 1886," p. 131.

(*Note.*—M. H. Hey in "Studies of the Zeolites, Part II."[1] states "Sloanite is another species set up by Meneghini and Bechi (1852); their original analysis is very poor, but the description suggests laumontite, and this the British Museum specimen (b.M.31348, presented by the Chevalier Sloane in 1860) unquestionably is. E. Manasse (1906) analysed a specimen of natrolite under this name, and Dana (Syst. Min. App. II. 1909, p. 74) says this analysis proves sloanite to be a variety of thomsonite, a slip several authors have copied)."

[1] Min. Mag., Vol. XXIII., No. 137, 1932, p. 114.

11. STILBITE. Chem. Comp. $(Na_2Ca)\ Al_2\ Si_6\ O_{16} + 6H_2O$.
Crystalline form: Monoclinic. Sp. Gr. 2.094-2.205.

A. In basalt associated with Chabazite.

Loc. Toowoomba.

Ref. "Catalogue of the minerals exhibited in the Queensland Court, Colonial and Indian Exhibitions of 1886," p. 131.

See 3B.

B. Loc. On the Fitzroy River, Rockhampton.

Ref. "Catalogue of such minerals as are at present known in Queensland, with their principal associations and places of occurrence," by E. B. Lindon. Proc. Roy. Soc. Qld., Vol. 4, 1887, p. 67.

C. Associated with Haematite, Wolfram, Garnet, and Mica in lode in granite.

Loc. Eungella Station, Broken River.

Ref. "Report on the Geological Features of the Mackay District," by R. L. Jack. Geol. Surv. Qld., Pub. 39, 1887, p. 6.

D. (or Heulandite). In Quartz veins.

Loc. Plant's Shaft, Golden Gate Reef, 4 miles N.W. of Croydon Railway Station.

Ref. "Qld. Mineral Index," by B. Dunstan. Geol. Surv. Qld., Pub. 241, 1913.

See 6D.

E. Associated with Quartz, Laumontite, Calcite in veins and fissures, sometimes with payable gold in andesite.

Loc. Rainbow, Spec. and Golden Gate Leases, Cracow.

Ref. "Recent Developments at Cracow," by A. K. Denmead, Qld. Govt. Min. Jour., 1933, p. 238.

See 7D.

F. With Calcite, Pyrite, and Quartz in regular or irregular veins in andesite tuff and conglomerate.

Loc. Walhalla, 8 miles by road N.N.W. from Cracow.

Ref. "Recent Developments at Cracow," by A. K. Denmead. Qld. Govt. Min. Jour., 1933, p. 239.

G. In veins in granite with Quartz, Calcite, pink Kaolinic material and a waxy mineral resembling Halloysite.

Loc. Golden King Claim, Almaden.

Ref. "Golden King Claim, Almaden," by A. K. Denmead. Qld. Govt. Min. Jour., 1934, p. 75.

H. Occurs with Laumontite, Calcite, Pyrite, and Chlorite in andesitic lode material either as disseminated particles or as veinlets lining joint planes.

Loc. Mt. Coolon Goldfield.

Ref. "Mt. Coolon Goldfield," by C. C. Morton. Qld. Govt. Min. Jour., 1935, p. 199.

See 7E.

*J. In rhyolite.
Loc. Cave on south side of Glen Rock, Esk.
Ref. Univ. of Qld. Dept. of Geology Museum.

*K. Associated with Calcite.
Loc. Aramac.
Ref. Qld. Museum, Reference Collection.

12. THOMSONITE. Chem. Comp. $(Na_2\ Ca)\ Al_2\ (SiO_4)_2 + 2\frac{1}{2}H_2O$.
Crystalline form: Orthorhombic. Sp. Gr. 2.3-2.4.

A. In cavities in amygdaloidal volcanic rock associated with Prehnite, Analcite, and Laumontite.
Loc. Bowen River, about 50-60 miles S.S.W. of Bowen, at Pelican Creek, a branch of the Bowen River, and at Strathmore Creek.
Ref. "Report on the Bowen River Coalfield," by R. L. Jack. Geol. Surv. Qld., Pub. 4, 1879, p. 6.
See 1A and 7A.

13. ZEOLITES.
(References are sometimes found to Zeolites in general, the particular variety not being mentioned.)

A. A stellate group of Zeolites growing on Cassiterite.
Loc. Chance Mine, Watsonville.
Ref. "Catalogue of Minerals exhibited in the Queensland Court, Colonial and Indian Exhibition of 1886," p. 25.

B. In basalt.
Loc. Burleigh Heads, Point Danger, and Tambourine Mountain.
Ref. "Handbook of Queensland Geology," by R. L. Jack, 1886.

C. Associated with Prehnite in volcanic rocks, both basic and acid in the Lower Bowen beds.
Loc. Outcropping along the Nogoa River from Nandowrie Peak to Springsure.
Ref. "Geological Reconnaissance between Roma, Springsure, Tambo, and Taroom," by H. I. Jensen. Qld. Geol. Surv., Pub. 277, p. 14.

D. In geodes lined internally with Chalcedony.
Loc. Nanango.
Ref. E. O. Marks. Abstract Proc. Roy. Soc. Qld., August, 1926, p. xiii.

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