

**Zeitschrift:** Schweizerische mineralogische und petrographische Mitteilungen =  
Bulletin suisse de minéralogie et pétrographie

**Band:** 37 (1957)

**Heft:** 1

**Artikel:** Stressed quartzite for silica brick

**Autor:** Amstutz, G.C.

**DOI:** <https://doi.org/10.5169/seals-29167>

### **Nutzungsbedingungen**

Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. [Mehr erfahren](#)

### **Conditions d'utilisation**

L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. [En savoir plus](#)

### **Terms of use**

The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. [Find out more](#)

**Download PDF:** 15.03.2026

**ETH-Bibliothek Zürich, E-Periodica, <https://www.e-periodica.ch>**

## Stressed Quartzite for Silica Brick<sup>1)</sup>

By *G. C. Amstutz* (Rolla, Missouri, USA)<sup>2)</sup>

About two years ago the writer introduced a research program at the Cerro de Pasco Laboratories in Oroya, Peru, with the aim of applying mineralogical principles to the solution of problems in silica brick manufacture. The purpose of the program was to improve the brick quality and lower the manufacturing and production costs. Improvement in the molding methods, the grinding and the particle size ratio, the burning time, the cooling rate, was attained. In addition, investigations concerned with the use of various "mineralizers" to give better conversion and the choice of raw material were undertaken. This note is a brief report on the results obtained in these two projects just mentioned.

The most severe difficulties during the manufacture of silica brick resulted from the high burning temperature and the long burning time. The kiln walls fell in frequently and the repair time on the kilns slowed production down seriously. Thus it was important to find a material which would convert at a lower temperature and in a shorter time. It was known from the literature that the addition of "mineralizers" would cause the quartz to convert faster and at a lower temperature. The following "mineralizers" were tried in two ways — with lime addition only and with lime and clay addition: sodium chloride, sodium carbonate, blast furnace flue dust, phosphorite, anhydrite, gypsum, titanium oxide, magnesia, reverberatory slag, coal dust. Best conversion and at the same time best strength were obtained with phosphorite and lime, and with reverberatory slag and lime with clay slurry. Fair results were also obtained from anhydrite with lime, gypsum with lime, titanium oxide with lime, magnesia with lime and clay. Sizing, molding, burning, etc. were exactly the same as for the usual bricks.

The next step, the search for the best raw material, yielded a result

---

<sup>1)</sup> Published with permission of Cerro de Pasco Corporation, La Oroya, Peru.

<sup>2)</sup> Missouri School of Mines and Metallurgy.

Formerly: Geologist, Cerro de Pasco Corporation, Peru.

which has not yet been found reported in the literature. Conventionally, a quartzite raw material is analysed chemically and its suitability determined from the  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{Fe}_2\text{O}_3$ ,  $(\text{Na}, \text{K})_2\text{O}$ ,  $\text{TiO}_2$ ,  $\text{CaO}$  content. Some companies examine the quartzite microscopically, but only to determine grain size and mineralogic composition, sometimes instead of, but often in addition to the chemical analysis. A mica or chlorite matrix, or too much iron oxide, outlaws any quartzite raw material immediately.

To the knowledge of the writer, no attention has been paid so far to the actual manner of interlocking of the quartz grains, the intra- and the inter-granular nature. Quartzites with exactly the same chemical composition can show a large variance in regard to the nature of the quartz grains, their internal quality and the properties of their surfaces.

In the course of testing various quartzites for silica brick manufacture it was evident that the stressed quartzite from Chuquipita was superior. This quartzite has undergone inhomogenic folding and some shearing during Andean orogeny. Recrystallization has probably released some of the strain but later tectonic movements have continued to stress the quartz grains. Therefore the quartz grains and their surfaces are still under a strain. This is evident microscopically from undulating extinction. The lattice and the surfaces of strained quartz are unstable or active and tend to convert much more easily into tridymite and cristobalite than "sound quartz". — The results obtained from this raw material were superior to those obtained with the best "mineralizers". It is known that pure quartz from quartz veins (98,5—99,5%  $\text{SiO}_2$ ) is not good material for brick making and this, I believe, is for the same reason: the quartz in veins is usually unstressed.

The result of this study suggests that mineralogic investigation can be of great value and should supplement chemical work during the evaluation of raw materials for silica brick.

#### Acknowledgement

The author is grateful to I. L. Barker, General Superintendent of Smelting and Refining, La Oroya, for his interest in this work, and to Cerro de Pasco Corporation for the permission to publish these results and photographs.

#### A SELECTED BIBLIOGRAPHY ON QUARTZITE, SILICA, AND SILICA BRICK

- BIRKS, L. S. and SCHULMANN, J. H. (1950): The effect of various impurities on the crystallization of amorphous silicic acid. *Am. Min.* 35, p. 1035—1038.
- BOLE, G. A. et al. (1927): Problems in the firing of Refractories. *U. S. Bur. Mines Bull.* 271, 197 p.

- BRADLEY, R. S. (1940): The principal physical tests for fireclay refractories. *Brick & Clay Record*, 15 p.
- BUERGER, M. J. (1951): Crystallographic aspects of phase transformations. In: TISZA, L.: *The general theory of phase transformations*. New York, p. 183—211.
- CHADEYRON, A. A. and REES W. J. (1939): *The Tridymitisation of Silica Bricks*. Iron and Steel Institute, Special Rept. 26, p. 205.
- CHRZAN, E. S., PETRIE, E. C. and SWAIN, S. M. (1952): Study of Silica Brick from a Glass Tank Crown. *Jour. Amer. Ceramic Soc.* 35 (7), p. 173—181.
- CLEMENTS, J. F. (1953): Firebrick and the reheat test. *Trans. Brit. Ceram. Soc.* 52, p. 117—128.
- CLEPHANE, P. F. F. (1942): Microscopic Determination of Silica Refractories. *Gas World*, 117 (3022), p. 118—122 (1942). *Gas Journal* 239 (4135), p. 282—288 (1942).
- COON, J. M. (1930): Microstructure of Some West of England Silicious Quartz Brick. *Trans. Brit. Ceramic Soc.* 29 (4), p. 125—137.
- (1933): *Microscopy of Silica Brick with Special Reference to the Inversion Forms of Silica*. *Colliery Guardian*, 147 (3806), 1.096.
- EITEL, W. (1954): *The Physical Chemistry of the Silicates*. Univ. Chicago Press. 1592 p.
- ENDELL, K. and HARR, R. (1926): The Effect of Oxide Impurities upon the Physical Properties of Silica Brick. *Stahl u. Eisen*, 46, 52, p. 1870—1876.
- GREEN, A. T. and STEWART, G. H. (1953): *Ceramics. A Symposium*. Brit. Ceramic Soc. Stoke-on-Trent. 877 p.
- GRIMSHAW, R. W. (1953): Quantitative Estimation of Silica Minerals. *Clay Minerals Bull.* 2 (9), p. 2—7.
- HARBISON-WALKER REFRACTORIES COMP. (1950): *Modern Refractory Practice*. Pittsburg, Penn. 439 p.
- HAUTH, W. E. (1951): Crystal Chemistry in Ceramics. *Am. Ceramic Soc. Bull.* 30, p. 5—7, 47—49, 76—77, 137—139, 140—142, 165—167, 203—205.
- HEWITT, D. F. (1951): Silica in Ontario. *Ont. Dep. Min. Industr. Miner. Circ.* 2, Toronto (April 1951), 16 p.
- HIBSCH, J. E. (1926): Microscopical Examination of Quartzites and Lime — Quartz Brick (Silica Brick, Dinas Brick), *Fuerfest*, 2, p. 93—95, 113—117.
- HUGILL, W. and REES, W. J. (1925—26): The influence of Iron Oxide and Iron Sulphides on the Rate of Quartz Manufacture. *Trans. Ceram. Soc. (England)*, 25, p. 309—313.
- (1930): The Influence of Iron Borate on the Rate of Inversion of Quartz in Silica Bricks. *Trans. Ceram. Soc. (England)*, 29, pp. 299—303.
- (1931a): The Influence of Iron Oxide on the Rate of Quartz Inversion in Lime and Limeclay Bonded Silica Bricks. *Trans. Ceram. Soc. (England)*, 30, pp. 321—329.
- (1931b): A Further Note on the Influence of Iron Oxide on the Rate of Quartz Inversion in Lime and Lime-clay Bonded Silica Bricks. *Trans. Ceram. Soc. (England)*, 30, pp. 330—336.
- (1931c): The Influence of Titanium Dioxide on the Rate of Quartz Inversion in Limebonded Silica Bricks. *Trans. Ceram. Soc. (England)*, 30, pp. 347—350.
- INSLEY, H. (1955): *Microscopy of Ceramics and Cements (including Glasses, Slags and Foundry Sands)*. Academic Press, New York, 284 p.

- KAISER, W. F. (nach HUTTER, L.) (1951): Feuerfeste Steine für die Kupferindustrie. *Erzmetall* IV, p. 198.
- KEITH, M. L. and TUTTLE, O. F. (1952): Significance of variation in the high-low inversion of Quartz. *Am. Jour. Sci.*, Bowen, p. 203—252.
- KERR, P. F. and ARMSTRONG, ELIZABETH (1943): Recorded Experiments in the Production of Quartz. *Bull. Geol. Soc. Am.* 54, p. 1—34.
- KIEFER, C. (1952): Importance et influence de la nature minéralogique des constituents sur le comportement des masses céramiques. *Analyse minéralogique. Bull. Soc. française Céram.* 17, p. 14—33.
- KOEPPEL, C. (1938): Transformation Catalysis of Silica Acid in the Firing of Silica. *Mitt. Forsch. Anstalt, Gutehoffnungshütte Oberhausen A.G.*, 6, 8, p. 220—224.
- KRATZERT, J. (1950): Keramik, feuerfeste und säurefeste Erzeugnisse. In: WINNACKER, K. und WEINGAERTNER, E. *Chem. Technologie, anorgan. Technologie II*, p. 367—371 (Silicasteine).
- LAVES, F. (1939): *Natura*. XX. VII, p. 705 (and *Min. Abst.* VII, p. 514, 1940).
- LEWCOCK, W. and WYLDE, J. H. (1953): Behaviour of silica brick on reheating. *Trans. Brit. Ceram. Soc.* 52, p. 225—258.
- MCVAY, T. N. (1929): Optical Methods as an Aid to the Study of Refractories. *Jour. Amer. Ceramic Soc.* 12 (7), p. 455—456.
- MUDD-SERIES (1949): *Industrial Minerals and Rocks*. 2nd ed., A.I.M.E., 1156 p.
- NAGAI, S., OTA, Z., TANEMURA, F., TANAKA, S. and ARAI, Y. (1953): Studies on the Mikawa Quartzite for Silica Refractories. Part I: On the effect of Addition Agents as Mineralizers. *Jour. Ceram. Assoc. Japan* 60, No. 677, p. 476—480. Part II: On the Mineral Constitution of Silica Refractories. *Jour. Ceram. Assoc. Japan* 61, No. 683, p. 207—210.
- NORTON, F. H. (1942): *Refractories*. McGraw-Hill, New York, 798 p.
- (1952): *Elements of ceramics*. Addison-Wesley Press, Cambridge, Mass., 246 p.
- REES, W. J. (1925): Micro-examination of Steel-making Refractories. *Trans. Faraday Soc.* 21, p. 293—296.
- (1925—26): A Further Note on the Influence of Iron Oxide in Promoting the Inversion of Silica. *Trans. Ceram. Soc. (England)*, 25, p. 314—320.
- RIGBY, G. R. (1949): *The thin-section Mineralogy of Ceramic Materials*. Publ. by The British Refractories Research Association. 179 p.
- ROSS, D. W. (1919): *Silica Refractories*. Bur. Standards Tech. Pap. No. 116, 84 p.
- SALMANG, H. (1954): *Die Keramik*. Springer, Berlin.
- SCHOUTEN, C. (1951a): Microscopic Observations on Silica Brick. *Trans. British Ceramic Soc.* 50, p. 185—207.
- (1951b): The Reflecting Microscope as applied to some Ceramic Products. *Bull. Amer. Ceramic Soc.* 30 (4), p. 130—136.
- SOSMAN, R. B. (1927): The properties of silica. *Chem. Cat. Comp.*, New York, p. 813—821.
- SU LIANG-HO (1950): Mineralogical Study of the Corrosion of Checker Bricks from Open-Hearth Steel Furnaces. *Trans. Brit. Ceramic Soc.* 49, p. 420—454.
- A Symposium on Silica Inversions (1947—48): *Trans. Brit. Ceramic Soc.* 47, p. 269—291.
- THOMPSON, C. L. (1934): Quantitative Microscopic Determination of the Quartz Content of Commercial Ground Feldspars. *Jour. Amer. Ceramic Soc.* 17 (8), p. 257—258.

- VAN VLACK, L. H. (1948): Chemical and Mineralogical Changes in Stack and Hearth Refractories of a Blast Furnace 31 (8), p. 220—235.
- U. S. Bureau of Standards Technical Paper 116: Silica Refractories — Factors affecting their quality and Methods of Testing the Raw Materials and Finished Ware.
- WEIGEL, W. M. (1927): Technology and uses of silica and sand. Bull. 266, U. S. Bur. Mines, VI and 204 p.
- WEYL, W. A. (1951): Transitions. From: TISZA, L.: New York, p. 296—334.
- WOOD, J. F. L., HOULDSWORTH, H. S. and COBB, J. W. (1925—26): The Influence of Foreign Matter on the Thermal Expansion and Transformation of Silica. Trans. Ceram. Soc. (England), 24, 4, p. 289—303.
- ZSCHIMMER, E. (1933): Das System Kieselerde, Quarzgut und Quarzglas, Silikatsteine. Stuttgart, 146 p.

Received: January 2nd, 1957.

---

#### EXPLANATION OF PLATES I—III

- Plate I: Fig. 1. Stressed quartzite from Chuquipita. Undulating extinction of most of the quartz grains shows the tectonic stress which rests on them. The grain size is very uniform and many boundaries interlacing. Crossed Nicols. Enlargement 150×.
- Fig. 2. Poorly converted silica brick made from the old inhomogeneous, unstressed Huislamachay quartzite, also exhibiting poor sizing. Crossed Nicols. Enlargement 150×.
- Plate II: Fig. 3. Largely converted silica brick. Some islands of “metastable quartz” ( $N = 1.49—1.50$ ) have remained in a sea of minute cristobalite and tridymite crystals. Oroya silica brick made from Chuquipita quartzite (figure 1). Highest temperature reached: 1450° C, for about 20 hours. Crossed Nicols. Enlargement 150×.
- Fig. 4. Completely converted silica brick from the Oroya brick yard (kiln No. 4 – August 1954). The exceptionally high temperature reached was 1500° C. The large “arrow heads” of tridymite twins as well as the needles and fish-scale cristobalite are clearly visible. Crossed Nicols. Enlargement 135×.
- Plate III: Fig. 5. The northeastern limb of the quartzite anticline at Chuquipita, Central Peru (elevation: 4200 m). The quartzite is of Goyllar-Jatun age, and is underlain by metamorphosed limestone. At present the quartzite is mined at the top of the anticline, where it plunges below the surface.
- Fig. 6. Flat laying quartzite layers, close to the top of the anticline, Chuquipita, Central Peru. Thick quartzite layers are separated by chloritic seams consisting of tuffaceous material which may have provided the free  $\text{SiO}_2$  cementing the quartz grains of the quartzite. These  $\text{Al}_2\text{O}_3$ - and  $\text{Fe}_2\text{O}_3$ -rich seam have to be discarded during mining of high quality stressed quartzite.

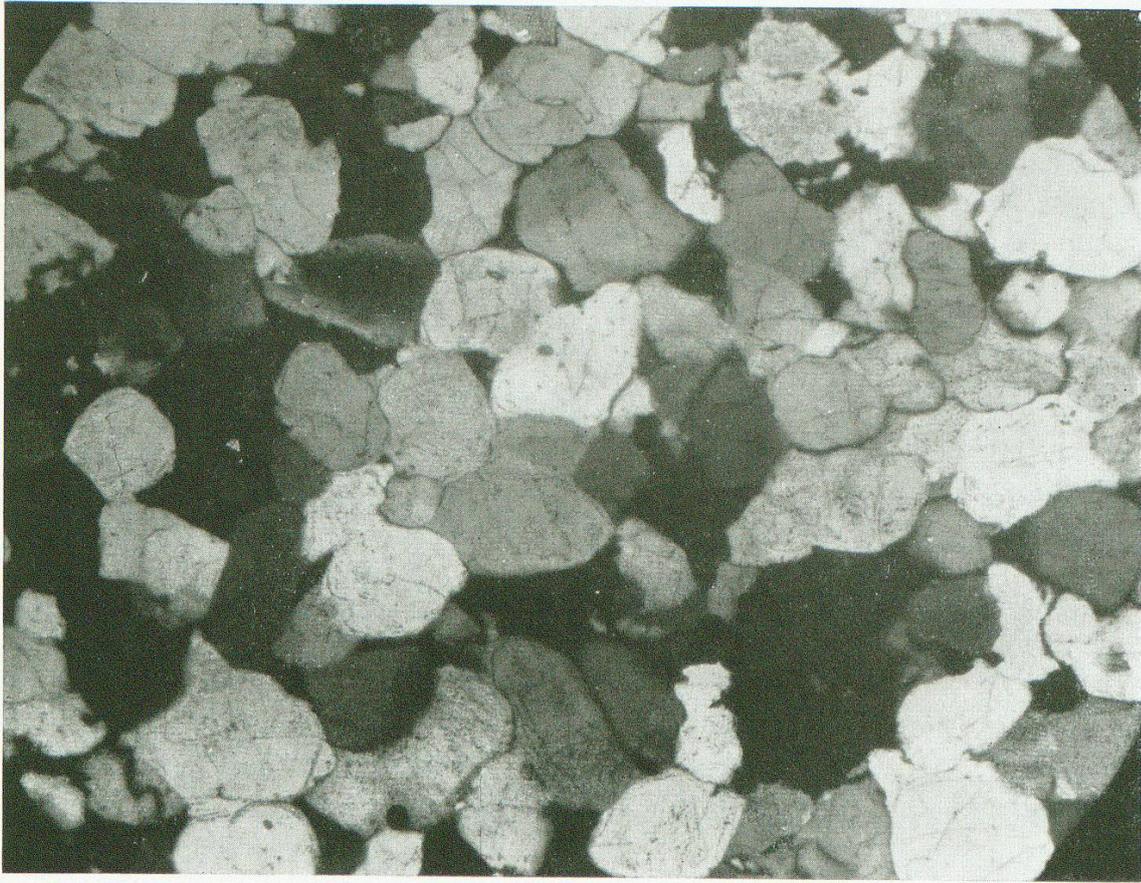


Fig. 1

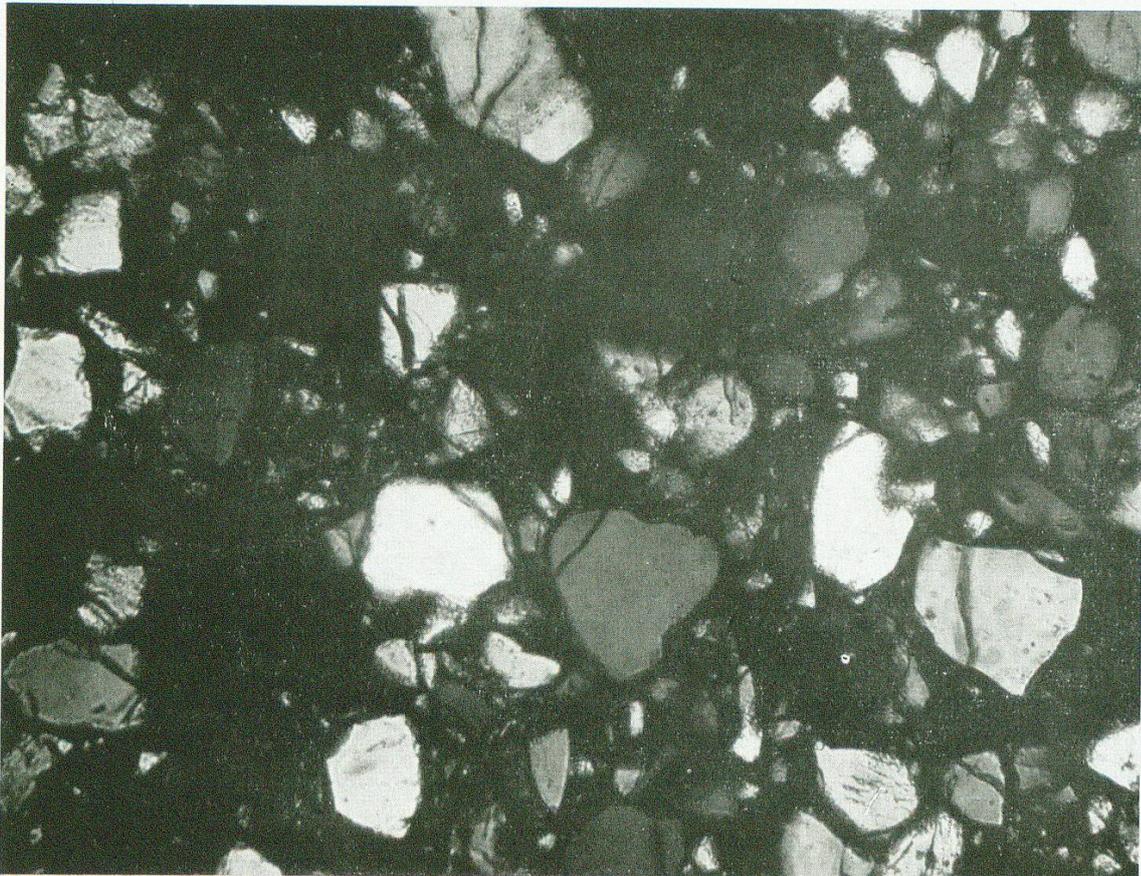


Fig. 2

PLATE II

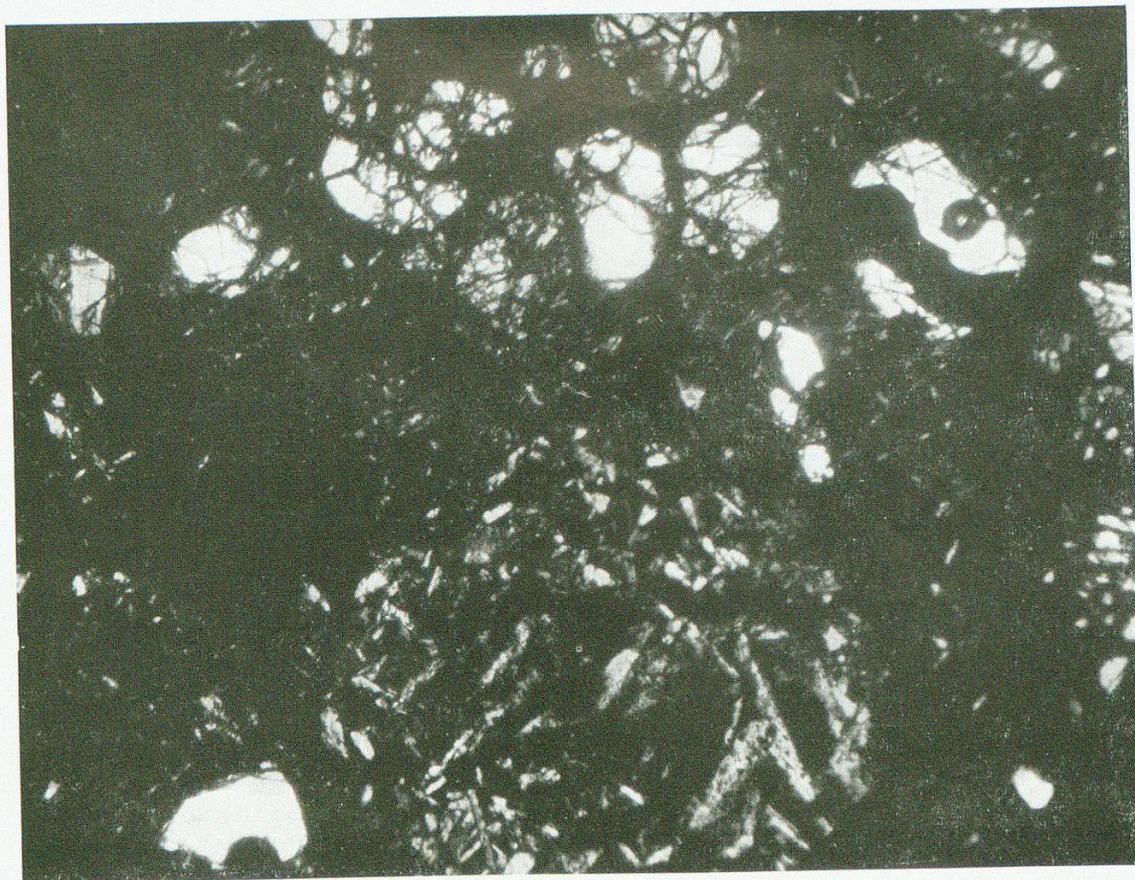


Fig. 3



Fig. 4



Fig. 5



Fig. 6