Note – *Notis*

Strength of experimentally deformed Adirondack anorthosite

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Seifert, K. E.: Strength of experimentally deformed Adirondack anorthosite. *Norsk Geologisk Tidsskrift*, Vol. 60 pp. 149–152. Oslo 1980. ISSN 0029-196X.

The strength of Adirondack anorthosite decreases with increasing temperature and increases with increasing confining pressure during deformation tests at 25°C and 0.5 to 1 kb and from 400°C to 1000°C at 5 to 17 kb with a strain rate of ca. 10^{-5}/second. Strength values range from over 20 kb at low temperatures to less than 1 kb in some high temperature tests. Cataclasis is the dominant mode of deformation in all tests although plastic flow occurs with increasing abundance at 800°C and above.

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The two samples of Adirondack anorthosite (AW-14 and TL-3) that were experimentally deformed have been largely to entirely recrystallized and have a relatively uniform and fine crystal size compared to typical Adirondack anorthosite. Microscopic examination of deformed cores indicates that careful hand sorting of TL-3 cores has eliminated those containing mafic minerals and that deformation of TL-3 was conducted on essentially pure polycrystalline plagioclase. Universal stage study shows that both samples have average plagioclase compositions around An_{50} and low to medium transitional structural states. Plagioclase in both samples has a mosaic texture and a predominance of albite and preicline twins typical of metamorphic rocks (Gorai 1950). Very little natural deformation other than the twinning is present in either sample although some healed cracks were occasionally observed. For additional information on the nature of the samples used for deformation and on the deformational features produced in these rocks, see Seifert & Ver Ploeg (1977).

Single crystals of plagioclase and anorthosites have been deformed in triaxial compression from 25°C to 800°C and 5 to 10 kb by Borg & Heard (1969, 1970). They found that the anorthosites generally exhibited a strength 1.3 to 3 times greater than single crystals, which is to be expected since they oriented their single crystals so that both albite and pericline twinning were permitted. A sample of Adirondack anorthosite was also deformed by Borg & Handin (1966).

Apparatus

The Griggs solid confining pressure apparatus used for all of the high temperature tests is capable of superimposed axial loads at confining pressures up to 20 kb and temperatures over 1200°C. Axial load can be applied at constant strain rates from approximately 10^{-4}/second to 10^{-7}/second by changing gear train connections. The samples used are very small right cylindrical cores approximately 2.95 mm in diameter and 7.62 mm in length. This type of apparatus has been described in detail by Griggs (1967) and Carter & Ave'Lallemant (1970).

The 25°C and 0.5 to 1 kb tests were conducted on a standard 120,000 1b Riehle press using a triaxial oil confining pressure chamber. Although the cores used in these tests were 12.7 mm in diameter, the length to width ratio was the same as the cores used in the solid confining pressure apparatus.

Strength data

Strength curves, presented as σ_1–σ_3, are given for the 25°C and 0.5 to 1 kb tests in Fig. 1. All cores deformed at these conditions failed by brittle fracture at angles near 30° to σ_1. The shear planes extended entirely across cores, thus terminating the tests at relatively low values of total strain. Only cores of TL-3 were deformed at these conditions.

Strength curves are given for both AW-14 and TL-3 at a constant strain rate of approximately 10^{-5}/sec over 200°C temperature intervals from 400°C to 1000°C and 4 kb confining pressure intervals from 5 kb to 17 kb in Fig. 2. Sample TL-3 has also been tested at 1200°C and 13 kb but not a sufficient number of times to present average strength curves. A brief summary of strength data for sample TL-14 has already been published (Seifert 1969), but those strength values were not reduced by the recommended 10% (Edmond & Paterson 1971) to account for the strength contribution of the talc-confining pressure medium. Strength values reported in Fig. 2 have been reduced 10% and each curve represents the average of 4 to 10 individual test runs. Good agreement between individual tests indicates that the strength contribution from the talc-confining pressure medium is nearly constant.

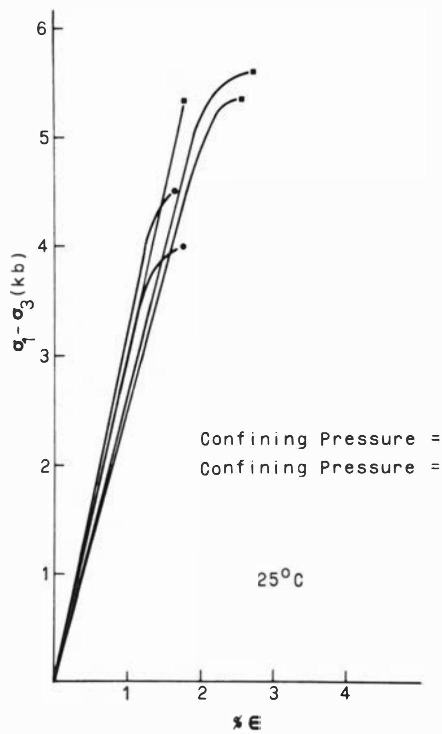

Fig. 1: Stress-strain curves for anorthosite deformed at 25°C and .5 and 1 kb confining pressure. Each curve represents a single test.

Discussion

At temperatures of 400°C and 600°C strain hardening continues to total strains as high as 14% in all cases, and the strengths of AW-14 and TL-3 are very similar. AW-14 is somewhat weaker but still considerably stronger than a sample of anorthosite with plagioclase of a similar composition (An_{44}) deformed by Borg & Heard (1970) at 600°C and 8 to 10 kb. At 800°C and 1000°C the strength of TL-3 is considerably greater than that of AW-14 and at total strains greater than 10 to 12% stress is sometimes constant or decreases for both samples at confining pressures of 5 kb. At higher confining pressures stress increases continuously.

Although the strength of TL-3 at 800°C and 9 kb is still much higher than the An_{44} sample of Borg & Heard, the strength of AW-14 at these conditions is similar but less. The few samples of TL-3 observed to contain mafic minerals also exhibited lower strengths similar to AW-14 and the AN_{44} sample. It seems reasonable to interpret the greater strength of TL-3 as representative of pure polycrystalline plagioclase deformed dry and the lower strength of the An_{44} sample as representative of more typical anorthosite with both plagioclase and mafic minerals. An Adirondack anorthosite containing both plagioclase and mafic minerals was deformed by Borg & Handin (1966) and exhibited strength values similar to the An_{44} sample, although their experimental conditions were 500°C and 5 kb.

However, the strength behavior of AW-14, an anorthositic gneiss with 5 to 10% mafic minerals in bands, is more complex. It behaves similar to TL-3 at 600°C or below and similar to the An_{44} sample at 800°C or above. Since the cores for deformation were usually taken from only the plagioclase bands, the difference between its strength behavior and that of TL-3 must be due to the much greater alteration of plagioclase in AW-14. Apparently the sericitic alteration material on plagioclase dehydrates between 600°C and 800°C, and the water weakens plagioclase as noted by Griggs (1967). Thin section observations of deformed cores from 800°C or higher tests reveal large increases in the amount of alteration, whereas the amount has remained constant in the 600°C or lower tests. Consequently the similarity in the strength behavior of AW-14 and the An_{44} sample at high temperatures may be fortuitous. Tests of AW-14 with mafic

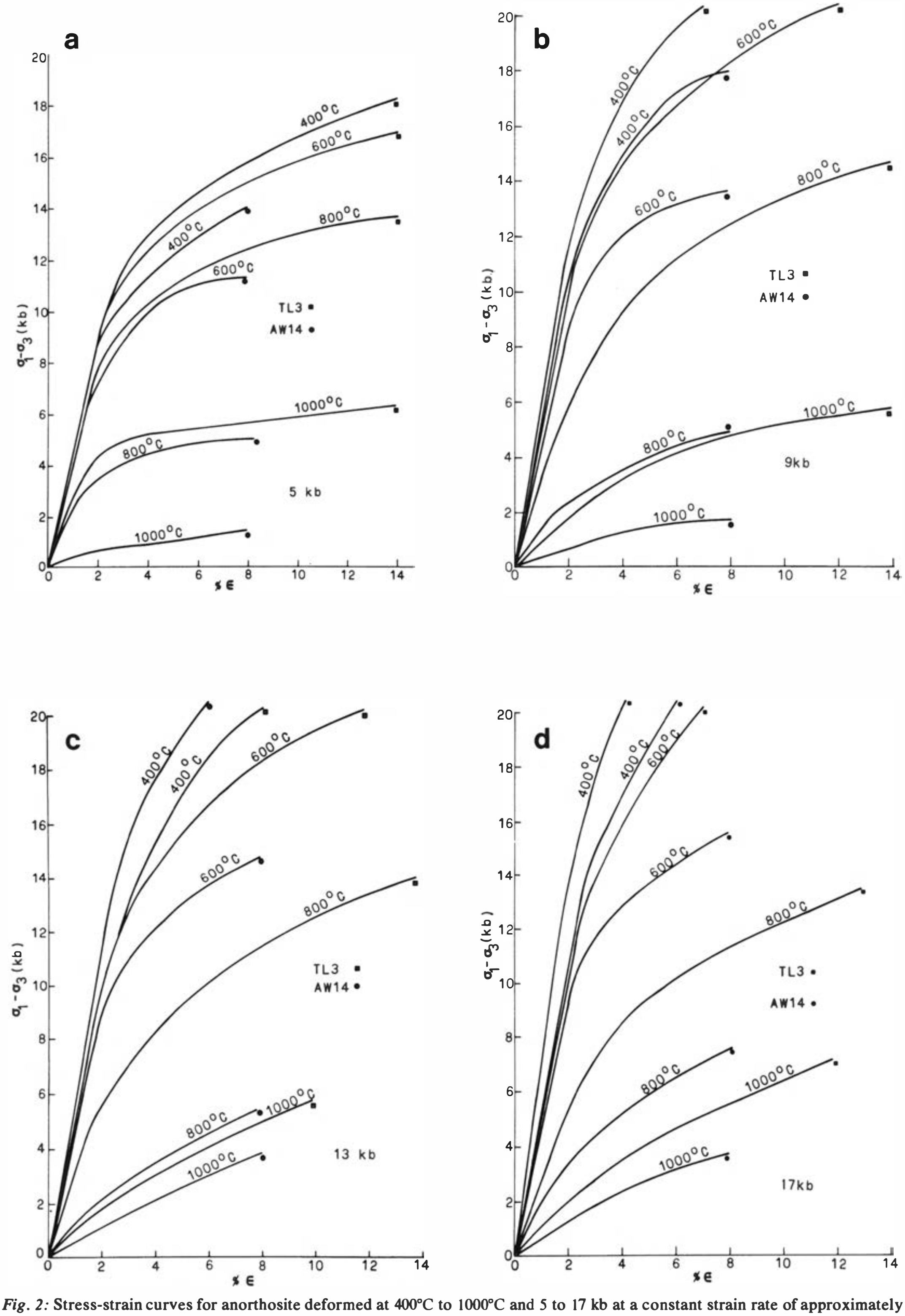

Fig. 2: Stress-strain curves for anorthosite deformed at 400°C to 1000°C and 5 to 17 kb at a constant strain rate of approximately 10^{-5}/second. Each curve is an average of 4 to 10 individual tests. a: Tests at 5 kb, b: Tests at 9 kb, c: Tests at 13 kb, d: Tests at 17 kb.

bands included show strengths of only a few hundred bars at 900°C or above.

Acknowledgements. – Financial support for this study was partially supplied by NSF Grants GA-712 and GA-4429.

January 1980

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