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Report for the period 4/1/92 to 6/31/92
DoE Grant DE-FG22-91PC91302
HYDROTHERMAL REACTIONS OF FLY ASH

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ABSTRACT

The reactions which occur when fly ash is treated under hydrothermal conditions will be investigated. This will be done for two primary reasons. The first of these is to determine the nature of the phases that form, to assess the stabilities of these phases in the ambient environment and, finally, to assess whether these phases are capable of sequestering hazardous species. The second reason for undertaking this proposed study is that, depending on the composition of the ash and the presence of selected additives, it may be possible under hydrothermal conditions to form compounds which have cementitious properties.

Formation of four classes of compounds, which bracket likely fly ash compositional ranges, have been selected for study. These are calcium silicate hydrates, calcium silicosulfates, calcium aluminosulfates, and alkali aluminosilicates. The specific compounds fabricated will be determined and their stability regions assessed. As a part of stability assessment, the extent to which selected hazardous species are sequestered will be determined. Finally, the cementing properties of these compounds will be established.

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PROGRESS

Ash Reactivity

During this period the reactivity of a high lime fly ash was further established. This effort follows up on an initial study to determine the intrinsic reactivity of this ash. This was done by isothermal calorimetry, hydrothermal treatment, x-ray diffraction, determination of mechanical properties. In the method used for calorimetry a known amount of ash (typically 3 grams) is placed in a gold plated copper calorimetric sample holder. This is then thermally equilibrated to the temperature of reaction. An aqueous reactant is separately equilibrated to the same temperature. Once equilibrium has been achieved, the liquid is inoculated onto the solid and the heat of reaction measured. These experiments were carried out at 38°C.

Results of calorimetric tests on the fly ash reacted with and without calcium sulfate is reported. The technique is used to identify and monitor the progress of reaction of fly ash reacted in the presence of calcium sulfate.

Figure 1 compare the rates of heat evolution during hydration of the ash itself and a mixture of the ash and $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ at 25°C. It can be seen that the high-lime fly ash has direct cementitious activity using heat evolution as the criterion of activity. However, calcium sulfate influences this behavior. Figure 2 shows the integral heat cures and these illustrate that the heat release is increased in the presence of calcium sulfate.

Figure 3 shows the effects of hydrothermal treatment at temperatures between 25 and 180°C on the ash itself. Changes are minimal. Figure 4 shows the effects of the presence of 10% calcium sulfate. Major changes occur and these are associated with the formation of ettringite, $3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 3\text{CaSO}_4 \cdot 32\text{H}_2\text{O}$. Ettringite is observed at temperature of 80°C

and below. Ettringite formation does not appear to occur above this temperature.

Mechanical Properties.

If ash is to be used in technological applications in many instances it is important that it develop mechanical properties. Bars of the high lime fly ash were fabricated and then subjected to extended hydrothermal treatments at 25, 60, 80, 110, and 180°C. After these treatments the bars were tests in flexure and the splitting strengths determined. The values obtained are shown in Figure 5. These data show that substantial mechanical properties can be realized by treatment of the ashes themselves and that these values are slightly enhanced in the presence of calcium sulfate. At a minimum these properties show that hazardous ashes could be consolidated to be handled. Further because ettringite may incorporate hazardous heavy metals, its formation could have a beneficial effect of the ability of an ash to sequester these. Alternatively, non-hazardous ashes could potentially be reacted to form useful products.

PLANNED WORK

In planned work the experimental efforts which have determined the effects of Ca(OH)_2 , monovalent alkali hydroxides and calcium sulfate will be written up for submission in the next quarter. It is also planned to evaluate activation of low lime ash. Effects of alkali and calcium sulfate will be examined. Further mechanical work will also be carried out. Experiments to evaluate the ability of ash to sequester hazardous heavy metals and semi-metals will be initiated.

Reporting Checklist

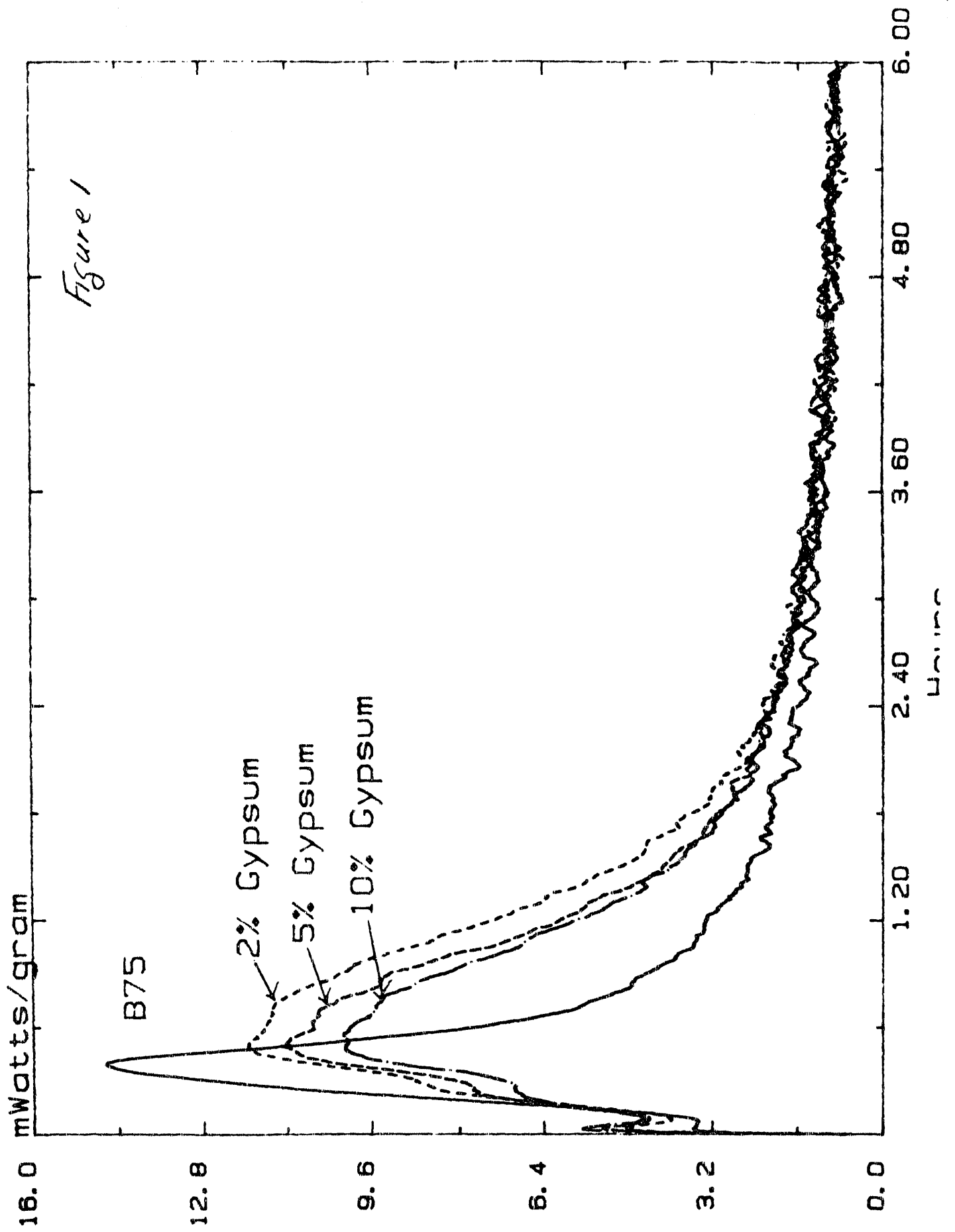
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Pittsburgh Energy Technology Center
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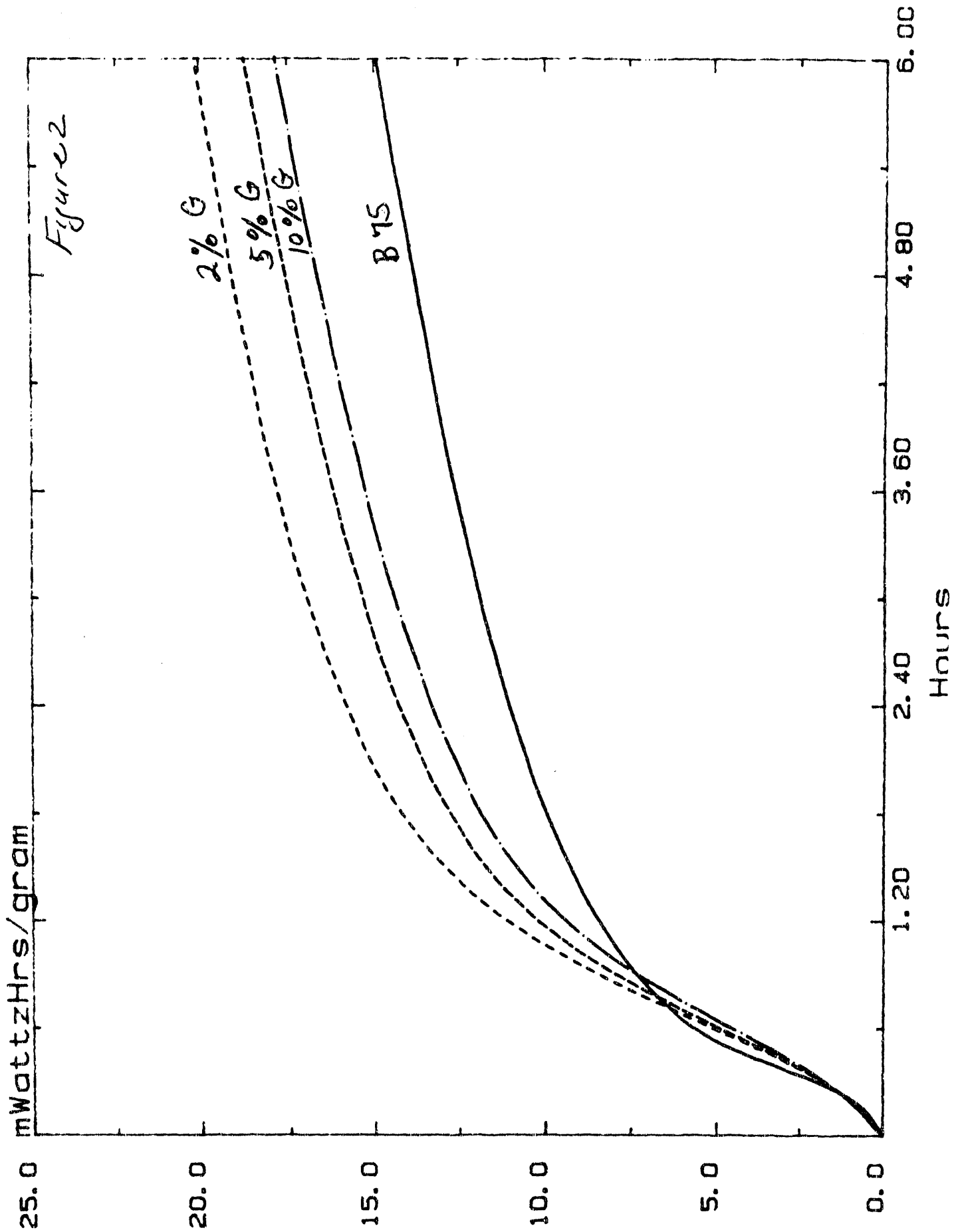
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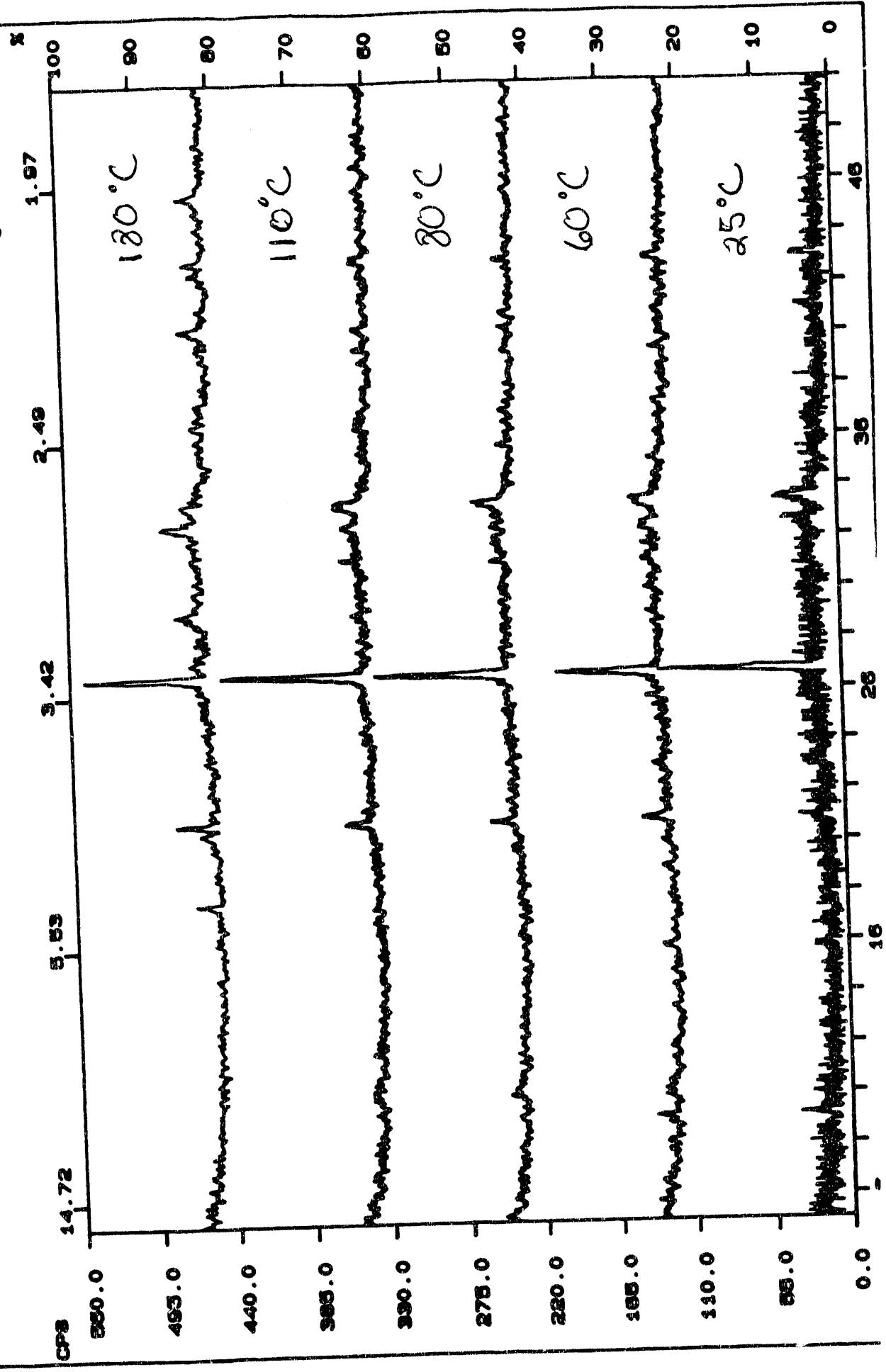
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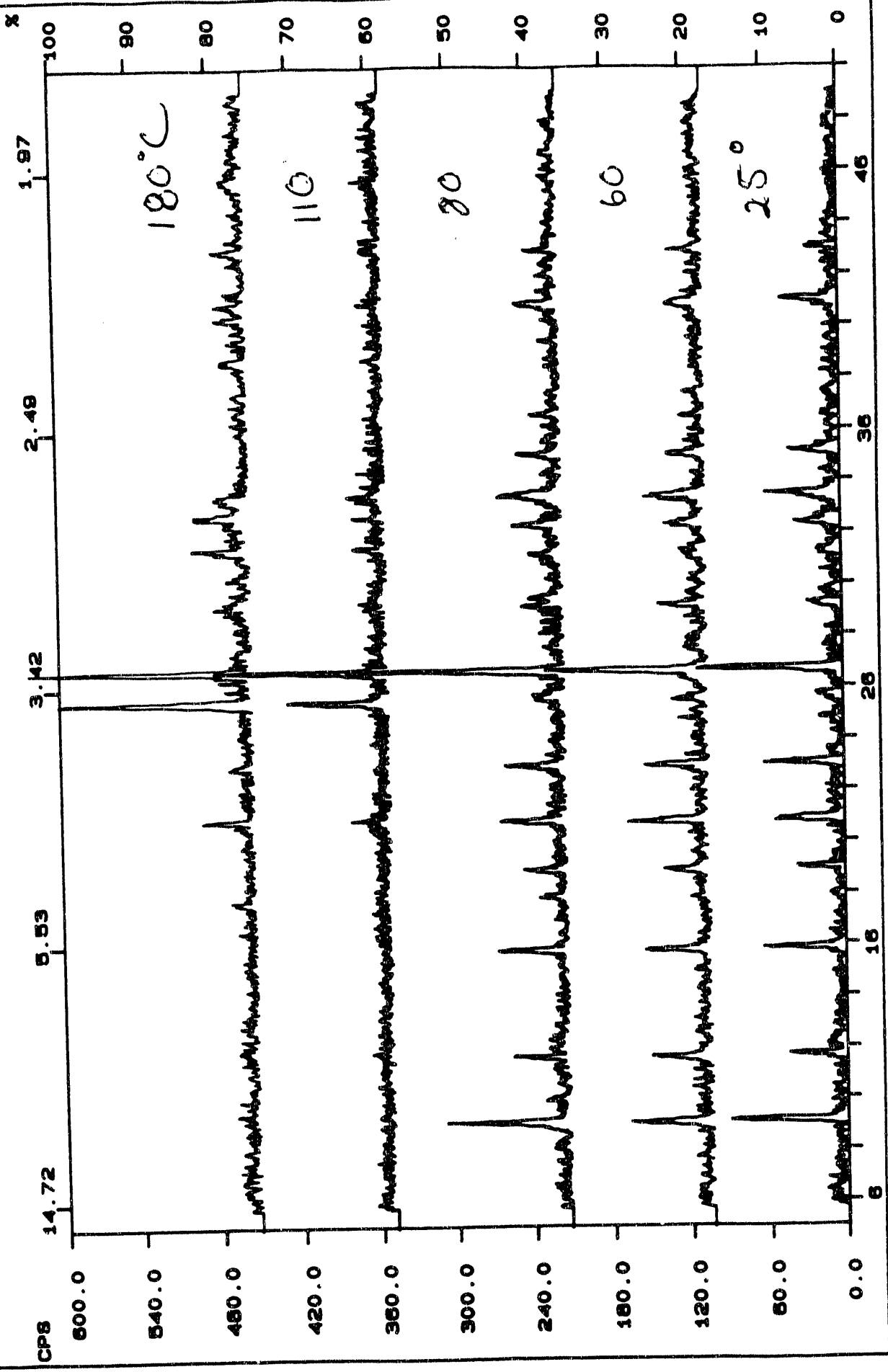
FN: f1y25c.r'd ID: FLYASH, B75, 25C SCINTAG/USA
DATE: 3/23/92 TIME: 14: 57 WL: 1.54059
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Figure 3



FN: ashgyp1.NI ID: FLYASH + 10% CASO4.2H2O 3D SCINTAG/USA
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Figure 4



Splitting strength under hydrothermal conditions

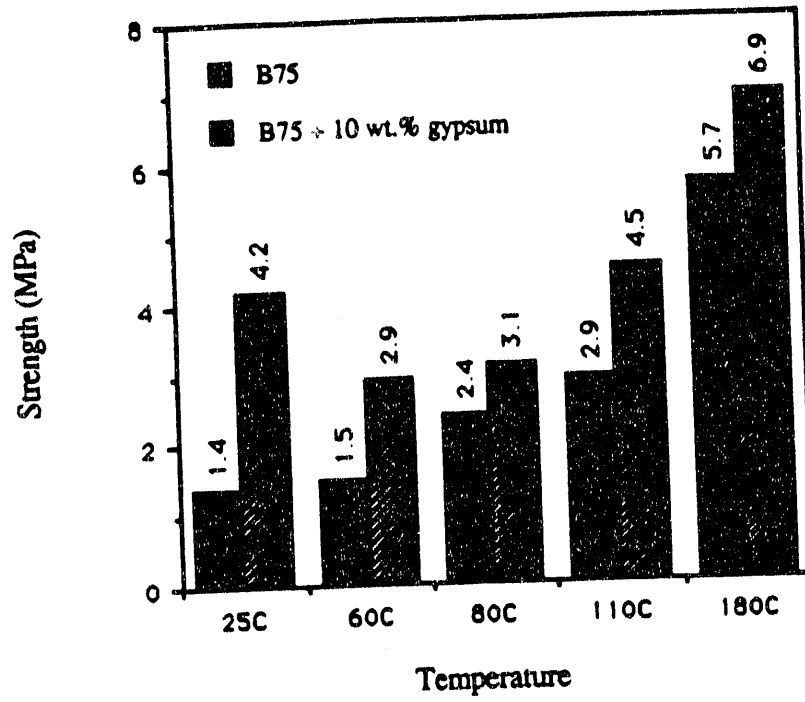


Figure 5

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