The igneous and metamorphic complex of Mid Pennar Project area is a square strip of country of about 42 square miles in the area lying between East Long. 77° 20' and 77° 25', North Latt. 14° 50' and 14° 58' in the northern part of the Survey of India topographic sheet No. 57 E/5. The complex comprises of metasediments, amphibolites, granite gneisses, granites, fault zone breccia, dolerite dykes and acid veins.

Various members in the metasediments represented by quartzites, chlorite schists, calc-chlorite schists, phyllites and intercalated ferruginous quartzites, are believed to represent original quartzose sandstone and interbedded shale, siliceous shale, calcareous shale and sandstone. At least some part of the amphibolites may possibly be para-amphibolites representing well-bedded series of dolomitic shale units probably containing some intermixed mafic tuffaceous material. The clastic sediments might have been partly derived from a source region of volcanic rocks.

Amphibolites and pyroxene plagioclase granulites are present as massifs, bands and lenticular patches associated with and within the extensive granite. Their field, petrographical, mineralogical and petrochemical characteristics reveal that they are metamorphosed igneous rocks ranging in composition from pyrosernit to quartz diorite.

The field, mineralogical and petrochemical characteristics of the granite and granodiorite gneisses suggest that they have
been formed by the migmatisation of amphibolites by the pro-
longed passage of fluids along certain channels.

From field observations, petrographic features and minera-
logical and petrochemical studies, it appears that a liquid of
granitic composition is the most likely progenitor for M.P.R.
granite, and it is believed to be an acid plutonic rock posses-
sing complex chemical characteristics of just the type to be
expected in rocks, crystallised from siliceous feldspathic
magnas with granitisation effects on a minor scale where such
magma has come into contact with the amphibolites.

The petrographic and mineralogical features of the fault
zone rocks are the sum of the processes controlled by orogenic
movement and differential stresses which were sufficiently power-
ful under the conditions of temperature at which the changes took
place to impress totally a new specific character on the rocks
affected, involving marked structural changes due to crushing and
shearing at low temperatures and extensive recrystallisation at
higher temperatures. The most important features include, the
different degrees of undulose extinction displayed by quartz,
induced secondary twinning in both plagioclase and microcline,
and finally elimination of twinning in feldspars—these are all
considered to be post-tectonic deformational features.

Dolerite dykes have intruded into the country rocks along
the pre-existing fracture zones. An attempt has been made to
relate the dyke pattern with the drainage pattern on a regional
scale. The wide spread distribution of the dykes suggests that
the basic material for their formation has probably been derived,
not from local pockets, but from some deep and more universal
layer; and such basic material may have been available throughout the area in sufficient quantities during the period of dyke formation; the dyke frequency being related to the proximity of the granite pluton. The petrographical and petrochemical characteristics suggest that they have resulted from the fractional crystallisation of eucrite magma which has switched over to tholeiitic line of descent.

Numerous quartz veins, pegmatites and aplites represent the youngest members of the area, and are interpreted as hydrothermal injections into both igneous and metamorphic rocks. These acid dykes and veins could well be a consequence of the intrusion of the magma as granite. It is quite probable that these acid dykes and sills represents the final phase of magmatic crystallisation of rather than emanations from granitic magma, and thus post-date the granite entirely.
APPENDIX

MID PENNAR RESERVOIR

An aspect on the Engineering Geology.

INTRODUCTION

The Mid Pennar Regulator (or Reservoir) Project is a part of Tungabhadra High Level Canal Scheme. This Project is intended to utilise the water of the Tungabhadra High Level Canal which enters Andhra Pradesh after traversing 68 miles of Mysore territory. In Andhra Pradesh this High Level Canal irrigates 35,000 acres of land upto the 116th mile. Here, it leaves a branch called the Guntakal Branch and cuts through Urevakonda ridge between Pennar and Hagari river basins and then drops into the Pennar river with a fall of 240 ft. The water thus led into the Pennar will be picked up by the Mid Pennar Regulator dam now under consideration. The north and south canals, with off takes from this dam, will run on the north and south sides of the Pennar river for 25 and 50 miles, respectively. The north canal irrigates 13,500 acres and south canal, 40,600 acres of land in the Anentapur District.

It is well known that, besides questions relating to the availability of construction materials for dam and water tightness of the reservoir, the most important consideration in the selection of dam site is the problem of foundation conditions.
It is not desirable to build a dam if the reservoir is not likely to hold water or if the foundation rock is not capable of bearing the weight of the dam. A reservoir, when full, exerts a considerable amount of water pressure, and unless founded on a suitable rock, the dam might fail causing considerable loss to life and damage to property. The area to be flooded should be geologically examined in detail, with a view to ascertain the possibility of serious leakages under hydrostatic pressure. Foundation conditions must be carefully investigated and weak formation or geologic structures, liable to cause sliding or subsidence of the dam foundation, should be avoided. All structural features such as bedding planes, faults, joints, fissures, crushed zones etc., will have an important bearing on the dam foundation.

**PROPOSED DAM SITE:**

The dam was originally proposed to be constructed at a site half a mile upstream of Konamanayanipalli village. Here the site was originally selected for a storage capacity of 925 M.c.ft., with the F.R.L. at + 1175 and T.B.C. at + 1219 respectively. The height of the dam was intended to be increased from 64 feet to 108 feet.

**GEOLOGY OF THE DAM SITE:**

Along the alignment where the dam was proposed to be constructed, only the abutments and their steep slopes expose rocks comprising massive chloritic quartzites and amphibolites.
with small lenses of massive to banded, mottled and ferruginous quartzites (vide plan, and section in fig. 1 & 2). The foliation in these rocks is obscure, except along the lenses of the quartzite and chlorite schist. The rocks are massive, hard, fine to medium grained and possess numerous closely spaced joints; a few of them are given below:

<table>
<thead>
<tr>
<th>N 55 W</th>
<th>55 E</th>
<th>Dipping</th>
<th>82-88</th>
<th>1&quot; to 4&quot; apart</th>
</tr>
</thead>
<tbody>
<tr>
<td>N 75 W</td>
<td>75 E</td>
<td>&quot;</td>
<td>54-vertical</td>
<td>1&quot; to 3&quot; apart</td>
</tr>
<tr>
<td>N 40 W</td>
<td>40 E</td>
<td>&quot;</td>
<td>71-85</td>
<td>½&quot; to 3&quot; apart</td>
</tr>
<tr>
<td>N 10 W</td>
<td>10 E</td>
<td>&quot;</td>
<td>63-vertical</td>
<td>1½&quot; to 1¾&quot; apart</td>
</tr>
<tr>
<td>E -- W</td>
<td>-</td>
<td>&quot;</td>
<td>55-75</td>
<td>¼&quot; to 3&quot; apart</td>
</tr>
<tr>
<td>N -- S</td>
<td>-</td>
<td>&quot;</td>
<td>45-75</td>
<td>1&quot; to 3&quot; apart</td>
</tr>
<tr>
<td>N 75 E</td>
<td>75 W</td>
<td>&quot;</td>
<td>60-vertical</td>
<td>½&quot; to 1&quot; apart</td>
</tr>
</tbody>
</table>

On the right abutment a chloritic band, 100 ft. wide, runs in N 25 W direction from R.D., 1880 and 50 ft. upstream and then tapers gradually to 10 ft. near R.D., 1600. Another band, 20 ft. in width branches off from the main one along R.D., 1780 and 40 ft. downstream and runs in a N 5 E direction.

The section from the right bank near R.D., 1600 to the left flank up to R.D., 650 is covered by alluvium. In the river bed, the alluvial cover consists of medium to coarse sand. Higher up from R.D., 200 to 900 there are isolated out crops of
massive metasedimentary rocks and the rest is concealed by soil and rock talus.

**EXPLORATORY WORK:**

**Bore holes:**

Exploratory work of bore holes was carried out by Public Works Department (Irrigation). Nine bore holes with calyx drill were put down along the axis of the dam. Two of these bore holes are on the right flank at R.D., 1900 and 2190. These bore holes have revealed that in the river bed, the sound rock level extends down to depths ranging from 12-27 ft., the deepest being in the middle of the river at R.D., 130/10. On the right flank, although the rock is exposed along the entire section, the sound rocks occur at depths ranging between 20 and 22 ft. The rock at this site possesses numerous closely spaced joints which are lined with chlorite, calcite and quartz. The cores usually break along these joints. Due to close jointing in the rock the core recovery is poor although the cores are from fresh and hard rock (fig. 13).

**Trial pits:**

Two trial pits were excavated by the Public Works Department at R.D.S., 850 and 750 and they were taken to depths 5 and 7 feet respectively. These pits indicate that silt and sand cover is 3 and 3½ ft. respectively and beneath it is weathered rock.
A. Along the alignment, where the dam was proposed to be constructed, the entire length of right abutment exposes massive chloritic quartzites, amphibolites, chlorite schists and quartzites. The last two occur in small lenses and bands. This foliation is more or less parallel to the axis of the dam. But the rocks are closely jointed, jointed planes running along and across the axis of the dam. These rocks show weathering down to a depth of 25 ft.

B. The river bed is covered by sand, the thickness of which varies from 7 ft. to 18 ft. Underlying this is a zone of weathered rock extending to depths of 5 to 10 ft. In all, the deepest zone of the cover and weathered rock may approximate 28 to 30 ft. to reach fairly good rock for foundation purposes.

C. The left flank for a length of 1000 ft., rises with a very gentle slope and then rises into a steep hill. Along this section, there is a cover of soil and rock talus with a thickness of about 3 ft. Beneath it, the rocks are similar to those which are exposed on the right flank. They also show weathering down to a depth of about 7 ft.

D. Along this alignment, to construct a dam with a height of 108 ft. is not feasible as the cost of construction would increase considerably for the following reasons.
(a) Stone quarries are located 5-6 miles away from this dam site.

(b) The major portion of the dam will be built of earth materials. These will have to be brought from distant places.

(c) The rocks in the foundation below over burden consisting of sand, soil and weathered zone, are jointed and fractured and weathered zone extends down to a depth of 10-27 ft. The excavation will have to be taken down to the sound rock level to a maximum of 30 ft. Grouting for consolidation will have to be done in the foundation both along the masonry and the earth sections.

(d) The right flank runs into a narrow ridge with cross drainage on either side of it. In these reaches considerable filling will have to be done to safeguard against leakages etc.

Probably due to these reasons partly, or wholly, the construction of a storage reservoir has not been taken up and the site was abandoned.

THE PRESENT DAM SITE:

An alternative dam site was proposed two miles upstream of the Konamanayanipalli village. The construction of the dam is nearing completion (in September, 1965). Along this alignment the river flows nearly west to east with more or less flat bed. The
width of the river bed is 860 ft. One main water course, 70-100 ft. wide, flows close to its right bank and another, a small one, crosses the axis of the dam at R.D., 2650 and then flows close to the left massive and jointed rock with numerous, small sand pockets. The right flank has a steep slope and is covered by solid and rock talus. The left flank is 45 ft. high from the river bed. It has a steep slope for a length of 100 ft. and then it is more or less flat with a low saddle, 1020 ft., between R.D., 950 and R.D., 1970. The entire left flank exposes massive, disintegrated and jointed rock (fig.3,4&5).

GEOLoGY OF THE DAM SIIE:-

Along the alignment the entire left flank and the river bed upto R.D., 3200 exposes rocks of the Dharwar suite consisting of undifferentiated amphibolites and chlorite schists. There are lenses of granite gneiss in them and dolerite dykes run across them. The river bed between R.D., 3200 and 3330 is covered by silt, sand and boulders. The right flank is covered by soil and rock talus fig.

The contact of the main chlorite schist band with the undifferentiated massive Dharwar suites of rocks is encountered at R.D., 30 and 40 ft. down stream. It runs continuously in NW-SE direction and its schistosity is also in the same direc-
Another 70 ft. wide band of ferruginous quartzite crosses the axes of the dam obliquely in a N 75 W direction between R. D., 670 and R. D., 750. This rock is quite fissile, banded and ptyctic and is much weathered. The foliation direction of the rock is N 75 W with easterly dips of 80°–95°. A second lens of chlorite schist, 10 ft. wide, occurs at R. D., 1900 and 130 ft. upstream. The strike of foliation is N 65 W.

Major portion of alignment of the dam site is in the Dharwar suit of rocks represented by the undifferentiated, massive, hard, amphibolites with numerous blotches and stringers of quartz epidote rock. These rocks are green, massive, fine to medium grained. They do not show any foliation except in the banded and schistose quartzites and chlorite schist. They are fractured and possess numerous closely-spaced joints, the details of some of which are given below:

<table>
<thead>
<tr>
<th>NW-SE</th>
<th>Dipping</th>
<th>65-86</th>
<th>( \frac{1}{4} )-4&quot; apart.</th>
</tr>
</thead>
<tbody>
<tr>
<td>N 75 W</td>
<td>&quot;</td>
<td>55-vertical</td>
<td>( \frac{1}{2} )-9&quot; apart.</td>
</tr>
<tr>
<td>N 55 W</td>
<td>&quot;</td>
<td>71-82</td>
<td>1&quot;-3&quot; apart.</td>
</tr>
<tr>
<td>N 15 W</td>
<td>&quot;</td>
<td>78-vertical</td>
<td>( \frac{1}{2} )-3&quot; apart.</td>
</tr>
<tr>
<td>N 55 E</td>
<td>&quot;</td>
<td>51-vertical</td>
<td>( \frac{1}{2} )-3&quot; apart.</td>
</tr>
<tr>
<td>N 10 E</td>
<td>&quot;</td>
<td>85-vertical</td>
<td>( \frac{1}{4} )-4&quot; apart.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>52-65</td>
<td>( \frac{1}{2} )-3&quot; apart.</td>
</tr>
</tbody>
</table>
A narrow band, about 10-15 ft. in width, of earthy grey porphyritic granite, trending S 15° W, is seen to extend from R.D., 2400 and 120 ft. upstream. The rock, composed of quartz feldspar and biotite, is quite fresh. A number of dolerite dykes traverse the dam site and these run in directions of parallel to N 40 W, N 70 W and N 55 W. They range in width from 6 inches to 65 ft. Two more or less parallel to dykes run for long distances. One of them, 5 ft. wide, crosses the axis of the dam at R.D., 1800 and swings in its trend between N 40 W and N 60 W. Another dyke, 65 ft. in width, runs along the axis line from R.D., 2100, 2200, 2300 and 2400 and then in S 70 E upto the left bank. In the river bed it is probably concealed by sand and again crops up on the left bank at R.D., 3400 and 200 ft. downstream. It then follows upon the left bank at R.D., 3400 and 200 ft. downstream.

EXPLORATORY WORK:-

Bore holes:-

The exploratory work carried out by Public Works Department includes bore holes and trial pits. Three calyx drill holes were put and two of them were drilled on the rock leges and core recovery in them was fairly high even from a shallow depth of 5 ft. The third bore hole was driven in a sand pocket where bed rock is met with at a depth of one foot. The cores from this bore holes
ROCK PROFILES

INDEX

- Alluvium
- Granite Gneiss
- Amphibolite
are fragmentary and the exposure is poor, but the fragments are from fresh and hard rock indicating highly jointed nature of the rock. The joint surfaces are stained with iron oxide material suggesting seepage of water down to the depth of the hole (fig. 5).

**Trial pits:-**

The trial pits occurred on the left flank exposed weathered rocks. In the river bed the trial pits have been located in the sand pockets and all of them have met with hard work at shallow depths. In the right flank the trail pits are 9-14 ft. deep and they show 1-5 ft. of soil and rock talus and below them hard, weathered rock. Fresh and hard rock levels were not determined.

**CONSTRUCTION MATERIALS:-**

For the masonry portion of the dam, rough granite stone is obtained from the western slopes of the Yerrakonda hillock about one mile west of the dam site and two and half miles from the abandoned dam site. Along the hill slope, the quarry face is 2600 ft. long and 200 ft. wide. At this place the granite is pink in color, massive and coarse-grained porphyritic type. The foliation in the rock is indistinct. The joints are 2 to 5
feet apart, thereby ealding large-sized blocks. The site for
quarrying of phasing granite stone is located two and half miles
due west of the present dam site and four miles from the aban-
dent dam site. At this place there are a number of low hill-
ocks extended for over a mile in W.N.W. direction. This hillocks
consists of light grey to light pinkish grey, medium grained granites.
The joints in the rocks are three to five ft. apart and this is
feature facilitates the quarrying of large-sized blocks to get
the required quantity.

CONCLUSIONS:

In summary it can be pointed out that the present site
where a dam is nearing completion consists of massive but highly
jointed and fractured rocks of the Dharwar suite comprising
chlorotic quartzites and amphibolites with bands and lenses of
chlorite schist, quartz schist and quartzite. Foliation in these
rocks is obscured but the joints and fractures cross the axis line
of the dam site. The present dam site has the following more
favorable geological and economic aspects.

a. Along the entire length of the present dam site,
hard rock occurs either at the surface or at reseanobly shallow
depths whereas there is an overburden of 18-27 ft. in the river
bed and in the right flank at the abandoneded dam site.
b. Major portion of the present dam site is in masonry as such the construction materials for this site or at comparatively closer distances than at the abundant site.

c. The earth material is in short supply. In the case of the old dam site which is mostly an earth dam, the construction materials will have to be brought from longer distances. This will considerable add to the cost if the old site is selected.

d. The present dam site provides a long and the convenient surplus section exposing hard rock at shallow depth. Further the surplus here can be led away by a natural drainage way back into the river two furlongs downstream of the dam. So an elaborate ogee spillway may not be necessary.

**SALIENT FEATURES OF THE MID PENNAR DAM:**

**Site:**

Two miles upstream, of Konamanayanipalli village and 27 miles from Anantapur town of Anantapur District in Andhra Pradesh.

**Catchment area at the M.P.R. site** : 2500 square miles.

**F.R.L. & M.W.L.**

: +1200.00

**Emergency M.W.L.**

: +1202.00

**T.B.L.**

: +1210.00

**Average bed level**

: +1100.00
Average bed level : +1100.00
Deepest foundation level : +1069.00
Top-width of Masonary dam : 15' 0"
Top-width of Earth Dam : 18' 0"
Width of Road-way between curbs over the masonry dam : 12' 0"
Total length of the dam : 3790' 0"
  a. Earth dam : 2100' 0"
  b. Masonry spillway : 690' 0"
  c. Masonry non-spillway : 1000' 0"
Water spread area at F.R.L. : 6358 square miles
Ayacut being localised 1/3 rd wet and 2/3 rd dry : 1,39,000 acres.

The left sluice has already been opened and the water has been let down for irrigation through the north canal, and thus the project has already been brought to partial benefit at an early stage of the construction. This project has provided employment for several hundreds of labouring people and it is hoped that it will give security to these areas against famine after its completion.