Comment: Dating of these formations has a bearing on the possibility or otherwise of oil-bearing strata in the region and on causes of the present-day coastal erosion. Samples will date emergence of the Kerala Coast also.

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MODIFICATION OF ALUMINIUM-SILICON ALLOYS BY MISCH METAL ADDITIONS

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THE modification of aluminium-silicon alloys by additions of small percentages of a few selected elements, particularly sodium, has been investigated by several workers[1–4] recently. The present work was planned to explore the possible role of misch metal, primarily as modifier and secondarily as beneficial alloying addition, in improving the quality of hyper-eutectic aluminium-silicon alloys. Earlier work[5] in our laboratory has already established the beneficial role of misch metal in refining the structure of Al-Cu and Al-Mg alloys.

Commercial aluminium of 99·5% purity and silicon of 99·0% purity were used in the present investigations. The misch metal contained 50–52% cerium, 20–22% lanthanum, 15–17% neodymium and 10–12% of other rare earth elements. This mixture of metals was preferred to one or more of the pure metals because of its low cost and easy availability, particularly in our country. A systematic study has been completed of the effects of this addition on the microstructure and mechanical properties at room and elevated temperature, both in the sand-cast and metal mould-cast conditions.

An aluminium—13% silicon alloy was first prepared. In each experiment, a sample of the alloy was melted in an induction furnace and held at 800° C. The required amount of misch metal wrapped in aluminium foil was plunged into the molten bath, agitated mildly and the casting made at 700° C. in a cast iron or sand mould, as desired. Routine mechanical testing methods were employed.

The results (Figs. 1–7) display the following salient features:

1. Misch metal additions seem to modify the structure appreciably in both sand-cast and metal mould-cast conditions (Figs. 1-6). There is little effect upto 0·5% addition (Fig. 2), but complete modification is obtained at about 1·0% addition (Figs. 3 and 6). With further additions, recoarsening of the eutectic takes place and some new phase makes its appearance in the microstructure (Fig. 6).

2. Tensile strength and percentage elongation at room temperature increase upto about 1·0% addition of misch metal and then decrease in both sand and metal mould-cast alloys (Fig. 7). The tensile strength of the alloy with 1·0% misch metal is 5 tons/sq. inch higher than the tensile strength of the sodium-modified alloy cast under the same condition.

3. Hardness also increases upto about 1·0% addition of misch metal, but remains almost constant upto 2·0% (Fig. 7). Further additions lead to a steady increase in hardness.

4. As at room temperature, tensile strength was found to increase appreciably at 200° C. upto about 1·0% misch metal addition and then to decrease. At 400° C the tensile strength was found to remain almost unchanged with misch metal additions.

Kim and Heine[1] have developed a growth temperature critical shape hypothesis for modification in Al-Si alloys. Their experiments indicate that the phase shape assumed by silicon

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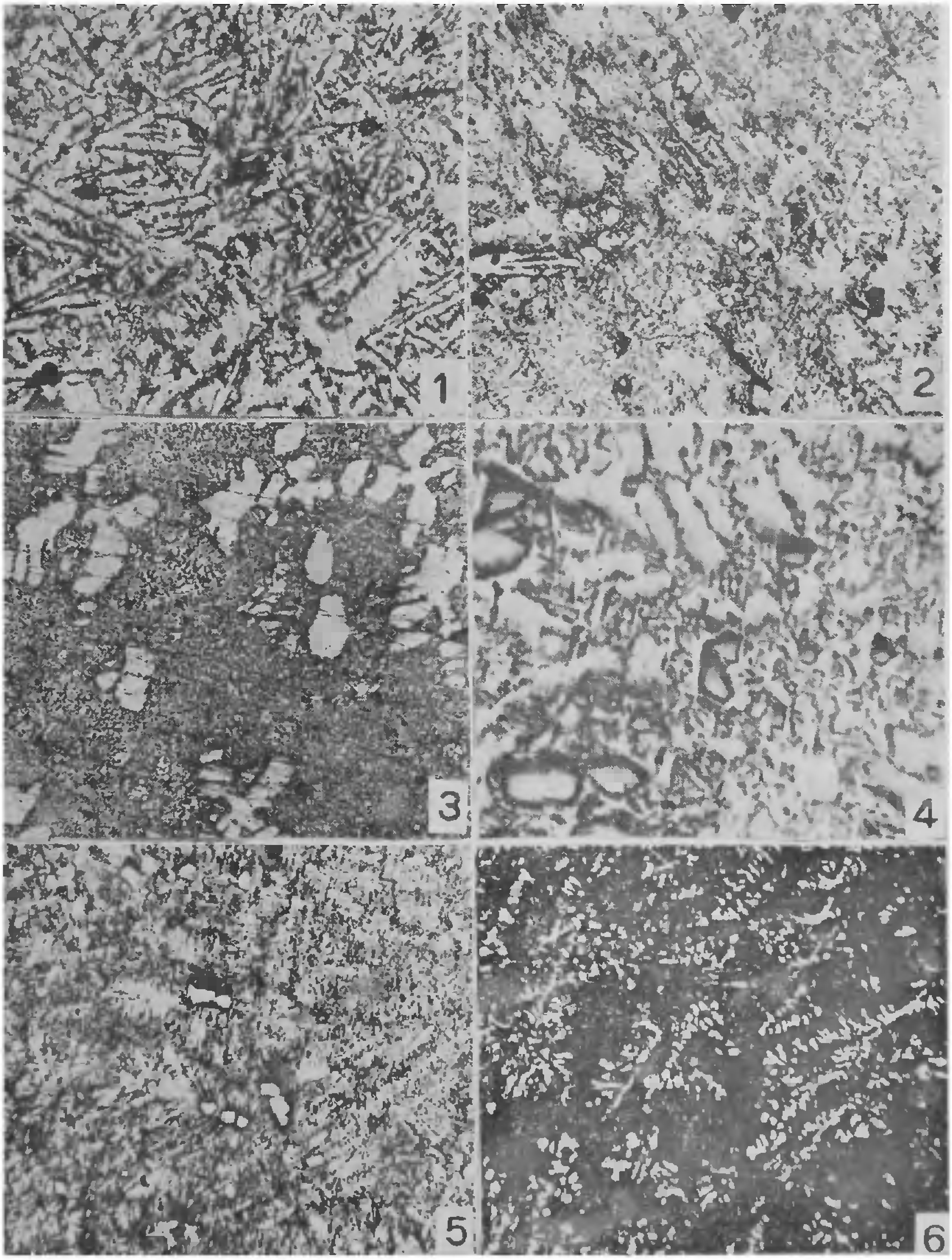
(polyhedral, coarse or fine plates in the normal eutectic and globular in the modified eutectic) is dependent on growth temperature. The polyhedral silicon or silicon plates in normal alloys are produced by the habit characteristics of the higher temperature of formation. The modifying element does not directly cause the globular shape in the modified eutectic, but



FIGS 1–6. Figs. 1–4. Microstructures of Al-13% Si alloy-sand-cast and etched with Keller's Reagent, × 100 Fig. 1. Without any modification. Fig. 2 With 0·5% Misch Metal addition. Fig. 3. With 1·0% Misch Metal addition. Fig. 4. With 4·0% Misch Metal addition. Figs. 5–6. Microstructures of Al-13% Si alloy-cast iron mould-cast and etched with Keller's Reagent, × 100. Fig. 5. Without any modification. Fig. 6. With 1·0% Misch Metal addition.

lowers the nucleation temperature to less than 500° C, where the globular shape grows naturally. According to them, the modifying element should have a tendency to form compounds with the precipitating phase at a temperature below the normal eutectic temperature. Further, the modifying element should have a low compound-forming tendency, low solubility and possibly a miscibility gap with the solvent phase.

Our experiments confirm that the unmodified microstructure consists of polyhedral silicon and coarse silicon plates (Figs. 1 and 5). With increasing misch metal addition, coarse silicon plates are converted first into fine plates and finally into globular ones with about 1·0% addition (Figs. 2, 3 and 6). The microstructure of the alloy treated with 1·0% misch metal consists of only the primary solid solution and globular fine silicon eutectic. If the temperature dependence of the silicon phase shape is valid, it easily follows that misch metal depresses the nucleation temperature of silicon. Small additions do not seem to be effective and depression to the temperature of globular growth is possible only with about 1·0% addition. Cerium is reported to dissolve upto 0·05% by weight in aluminium in the solid state, while lanthanum is reported to have no solid solubility in aluminium.[6] Thus very little of the cerium-lanthanum content of the misch metal goes into solid solution; most of it reacts with aluminium to form intermetallic compounds like Al_4Ce and Al_4La. The cerium and lanthanum may also react with the precipitating silicon phase to form compounds[7] like Ce_3Si, Ce_2Si, CeSi and $LaSi_2$. Thus the chief metals present in misch metal satisfy the requirements of a modifying element as laid down by Kim and Heine[1] except that these elements have also the tendency to react with the solvent phase to form intermetallic compounds. A higher percentage of misch metal than sodium is needed for modification possibly because of the tendency of the modifying addition to react with the solvent phase, thus inhibiting formation of stable silicon compounds. The nucleation temperature of silicon is depressed to the temperature of globular growth only with larger additions of misch metal when sufficient amount of modifying element is present to react with the silicon phase also. The presence of the primary alpha phase in these hyper-eutectic alloys can also be explained as by Kim and Heine.[1]

The gradual increase in hardness beyond 2·0% addition may be understood as due to the formation of fine particles of intermetallic compounds. The increase in tensile strength may

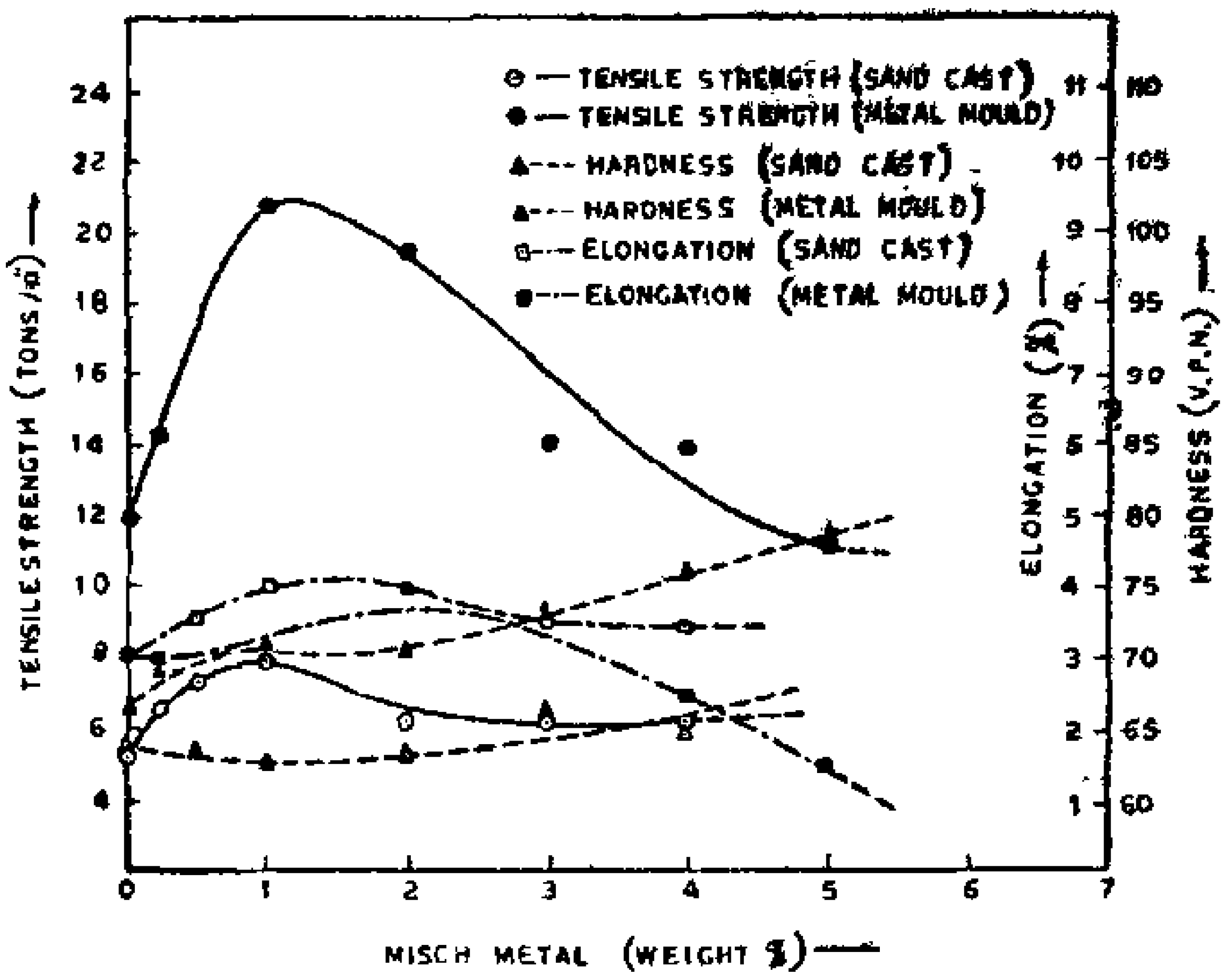


FIG. 7. Effect of Misch Metal additions on the Mechanical Properties of Al-13% Si alloy at room temperature.

be partly attributed to the modification and partly to the strengthening effect produced by the fine dispersion of harder intermetallic compounds like Al_4Ce and Al_4La, unlike in the sodium-modified alloy where the increase is attributed only to the modification of the structure. This also explains why a higher value of tensile strength has been recorded for the alloy treated with misch metal. The improvement in high-temperature tensile strength may also be due to these fine particles. The decrease in the tensile strength at room temperature beyond 1·0% addition may be due partly to the relatively increased amounts of intermetallic compounds and partly to the recoarsening of the matrix. The exact nature of the insoluble phases could not be confirmed in the present metallographic studies.

Hodge and Smith[8] have indicated that misch metal affects the surface tension and reduces the oxide film. Supporting evidence from contact angles and interfacial energies has, however, been ignored by Kim and Heine.[1]

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