Aluminium – Beryllium – Magnesium

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Literature Data

[1926Kro] investigated eight alloys by metallography and hardness measurements up to 3.21 mass% Be and 1.4 mass% Mg. The alloys were prepared in spinel crucibles, coated with Al_2O_3. The Al used contained 0.07 mass% Si and about 0.25 mass% Fe. The ingots were aged for 30 min at 550°C or 640°C, quenched in water and annealed for 48h at 150°C or 170°C, respectively. [1929Mas] studied the Al-rich corner by thermal and microscopical analysis of 10 alloys with constant Al content of 90 and 80 mass%. Two vertical sections and a partial liquidus surface were presented. Using the data of [1929Mas], partial isothermal sections at the ternary eutectic temperature, 449°C, at room temperature [1943Mon] and at a temperature slightly below 447°C (solid state) [1952Han, 1934Fus] were presented. In the review work of [1952Han] the Al-rich part of the liquidus surface including the four phase plane at 449°C were shown. Sections of the Al-Be-Mg system with 0.6, 10, 20, 30 and 50 mass% Be were investigated by thermal, chemical and microstructural analysis [1966Nag]. The stratification boundaries in the molten state were determined. Starting materials were 99.99% Al, 99.91% Mg and distilled 99.4% Be. The samples were prepared by using Al-Be and Al-Mg master alloys. The results of [1966Nag] were cited in the review work of [1966Age] and [1970Fri]. Mechanical properties such as the modulus of elasticity of Al-Be and Al-Be-Mg alloys were investigated by [1970Fri]. Hardness values were published by [1926Kro].
The present evaluation was published in the MSIT Evaluation Program earlier and reflects today's state of knowledge.

Binary Systems

The binary systems Al-Be, presented by [Mas] and Al-Mg by [1981Sch] are accepted and used as boundary systems.
The equilibrium phase diagram of the Be-Mg system has not yet been determined. A eutectic reaction l $\rightleftharpoons$ (Mg) + $MgBe_{13}$ is mentioned [1987Nay]. A sketch of this phase diagram is shown by [1976Mof].

Solid Phases

All stable phases are listed in Table 1.

Invariant Equilibria

A ternary eutectic reaction occurs at 449°C [1929Mas, 1952Han] (Table 2). It agrees with the data of [1966Nag] who determined it at 445 ± 3°C. Beyond this the reaction scheme contains a further tentative, very probable ternary invariant transition reaction L+$Be_{13}Mg \rightleftharpoons \gamma$+(Be). The invariant reactions of the binary Al-Mg system lead to degenerate ternary four phase equilibria (Fig. 1).

Liquidus Surface

The liquidus surface (Fig. 2) contains the partially tentative boundary line of the miscibility gap (L_1+L_2), reported by [1966Nag]. Its critical point as well as the tie lines are unknown.
Figure 2 shows the ternary eutectic point E and the likewise partially tentative lines of double saturation according to [1929Mas].

Isothermal Sections

Isothermal sections for the Al-rich part of the system were given by [1943Mon] for room temperature (Fig. 3) and by [1943Mon] and [1952Han] for T ~ 447°C after solidification. The section of [1952Han] is confined to about 35 mass% Mg and differs only in the homogeneity range of α, compared to the isothermal section at room temperature [1943Mon]. Mondolfo's section for $T \sim 447°C$ extends to about 40 mass% Mg. In the region 35 to 40 mass% Mg it has to be taken as tentative and is not consistent with the accepted boundary Al-Mg system [1981Sch].

Temperature – Composition Sections

Two vertical sections, partially tentative, at 90 and 80 mass% Al were presented [1929Mas]. The isopleths at 80 and 90 mass% Al are consistent with the accepted binary phase diagrams Al-Be [Mas] and Al-Mg [1981Sch]. The latter isopleth contains a three-phase-field α+β+(Be), whereas after [1981Sch] β does not occur in this composition range. The liquidus lines had to be lowered by about 30 K respectively at their start in the boundary Al-Be system (Figs. 4 and 5).
Three temperature-composition cuts for 50, 60 and 0.6 mass% Be were established [1966Nag]. The liquidus and solidus temperatures are corrected as well with respect to the binary Al-Be system [Mas] (Figs. 6, 7, 8).

References

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Table 1: Crystallographic Data of Solid Phases

Phase/ Temperature Range [°C]	Pearson Symbol/ Prototype	Lattice Parameters [pm]	Comments/References
(Be)(h) 1289-1270	*cI*2 $Im\overline{3}m$ W	*a* = 255.2	at 1260°C [L-B]
(Be)(r) 1270	*hP*2 $P6_3/mmc$ Mg	*a* = 228.66 *c* = 358.33	at 22°C [L-B]
δ, (Mg) 650	*hP*2 $P6_3/mmc$ Mg	*a* = 320.94 *c* = 521.03	at 25°C [L-B]
α, (Al) 660.5	*cF*4 $Fm\overline{3}m$ Cu	*a* = 404.96	at 25°C [L-B]
β, Mg_2Al_3 < 453	*cF*1168 $Fd\overline{3}m$ Mg_2Al_3	*a* = 2823.9	1168 atoms on 1704 sites per unit cell [2003Luk] 39.4 at.% Mg [L-B, 1981Sch] and [1982Mur]
ε, $Mg_{23}Al_{30}$ 450-428	*hR*159 $R\overline{3}$ $Mg_{23}Al_{30}$	*a* = 1282.54 *c* = 2174.78	[1968Sam, 1981Sch] 159 atoms refer to hexagonal unit cell [2003Luk]
ζ, $Mg_{48}Al_{52}$ 452-410	-	-	[1981Sch]
γ, $Mg_{17}Al_{12}$ ≤ 460	*cI*58 $I\overline{4}3m$ αMn	*a* = 1048.11 *a* = 1053.05 *a* = 1057.91	52.58 at.% Mg [L-B] 56.55 at.% Mg [L-B] 60.49 at.% Mg [L-B]
$Be_{13}Mg$	*cF*112 $Fm\overline{3}c$ $NaZn_{13}$	*a* = 1016.6	at room temperature [L-B] Al-Be-Mg

Table 2: Invariant Equilibria

Reaction	*T* [°C]	Type	Phase	Composition (at.%)		
				Al	Be	Mg
L ⇌ α + β + (Be)	449	E	L	67.86	0.02	32.12
			α, (Al)	88.28	0	11.72
			β, Mg_2Al_3	60.6	0	39.6
			(Be)	0	100	0

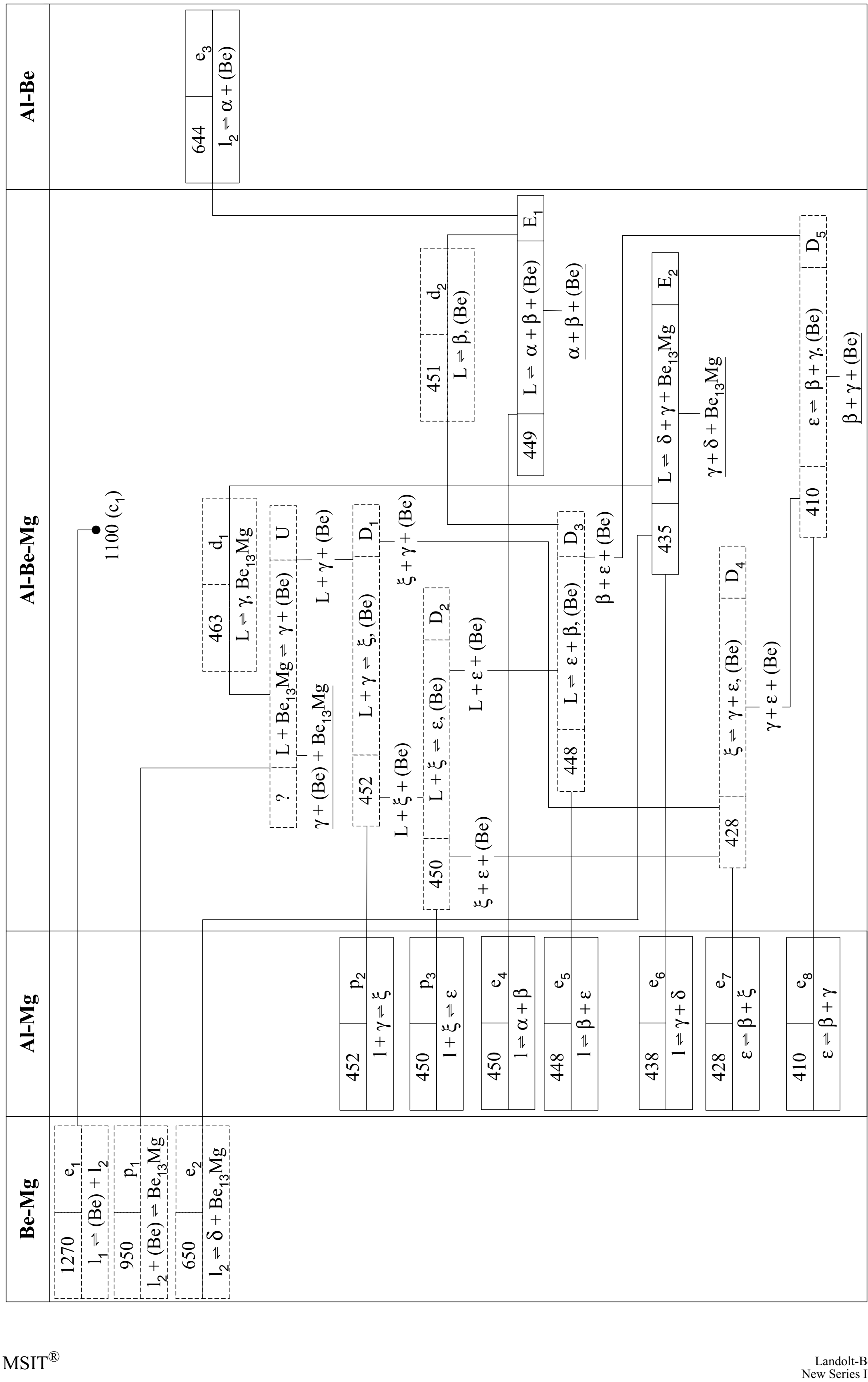

Fig. 1: Al-Be-Mg. Reaction scheme

Fig. 2: Al-Be-Mg.
Liquidus surface

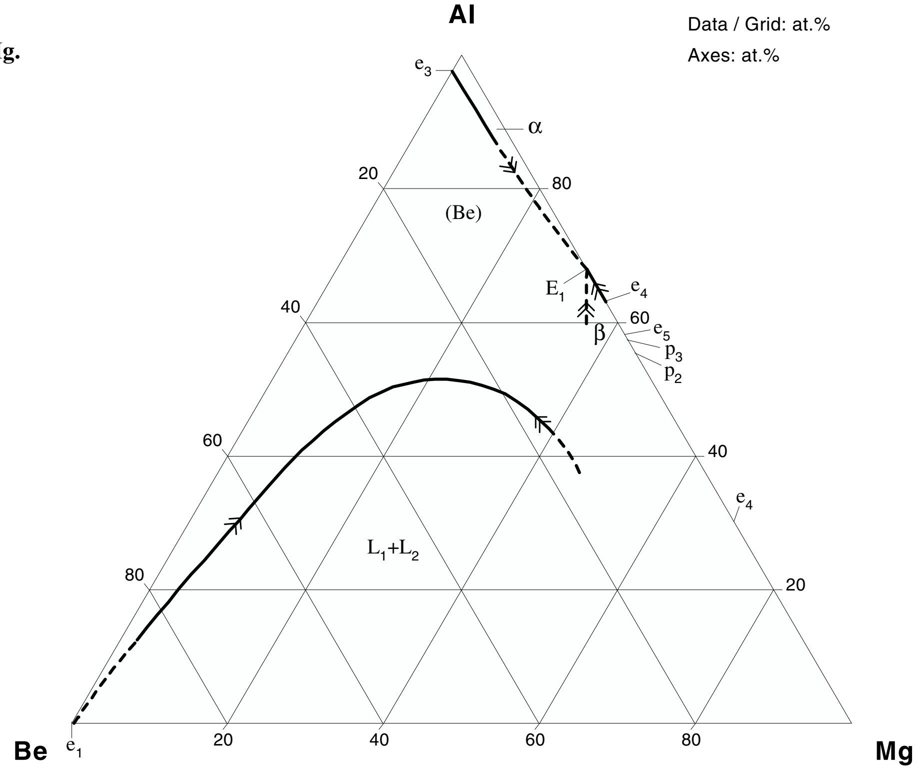

Fig. 3: Al-Be-Mg.
Isothermal section of the Al-corner at room temperature after [1943Mon]

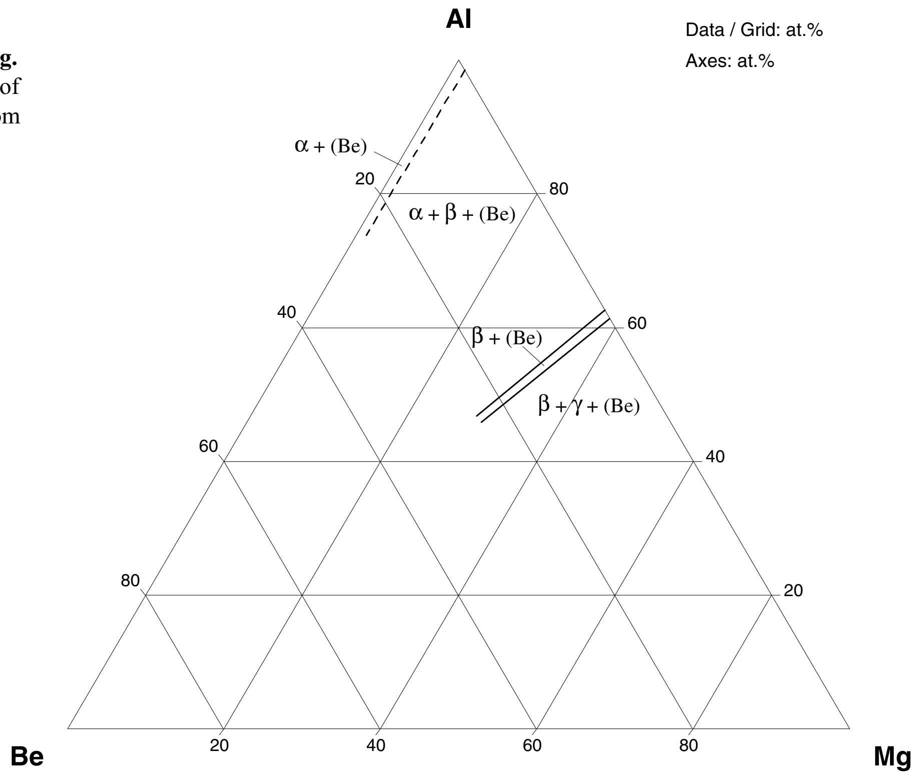

Fig. 4: Al-Be-Mg. Vertical section at 90 mass% Al [1929Mas]

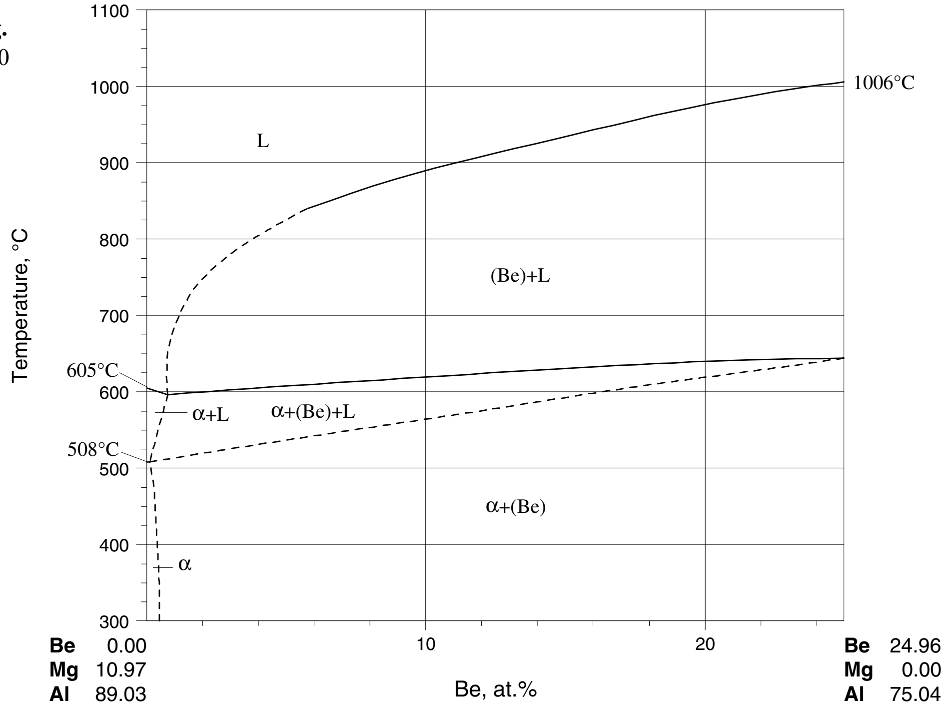

Fig. 5: Al-Be-Mg. Vertical section at 80 mass% Al; after [1929Mas]

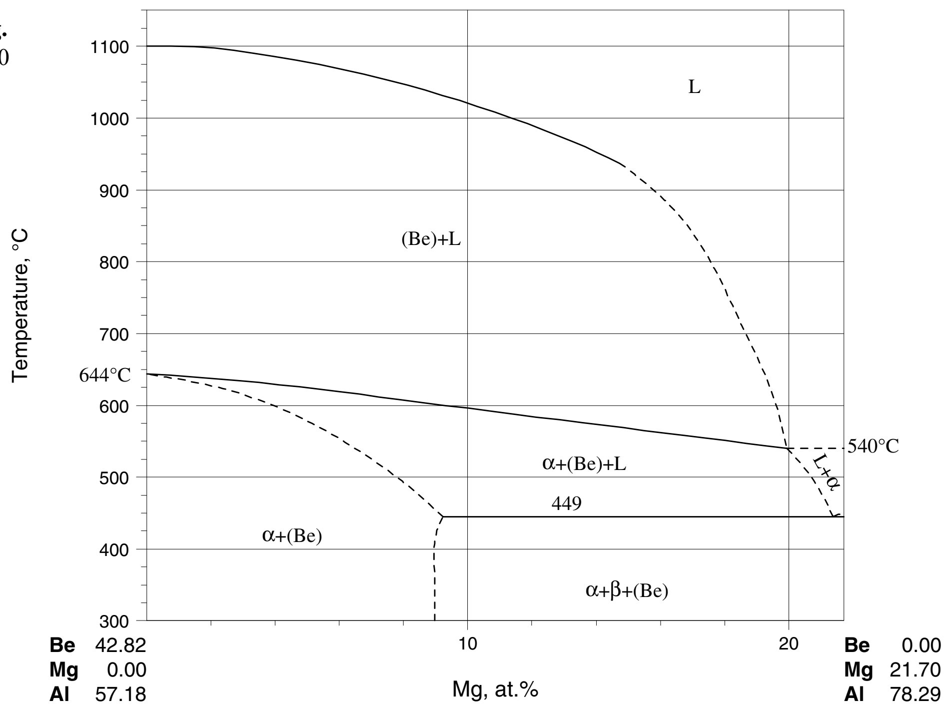

Fig. 6: Al-Be-Mg. Partial vertical section at 50 mass% Be; after [1966Nag]

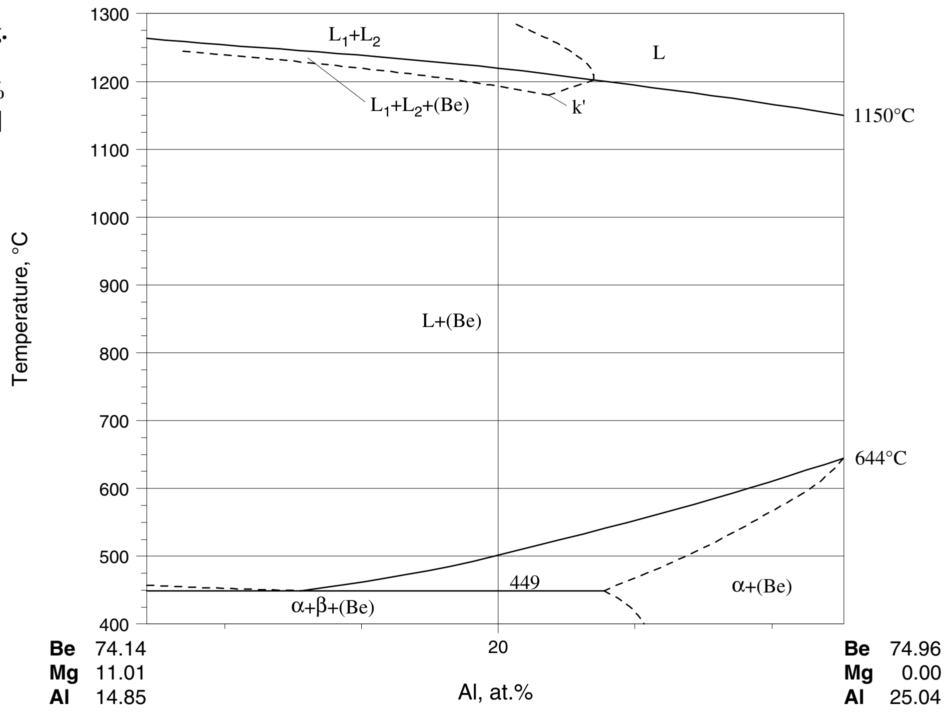

Fig. 7: Al-Be-Mg. Partial vertical section at 20 mass% Be; after [1966Nag]

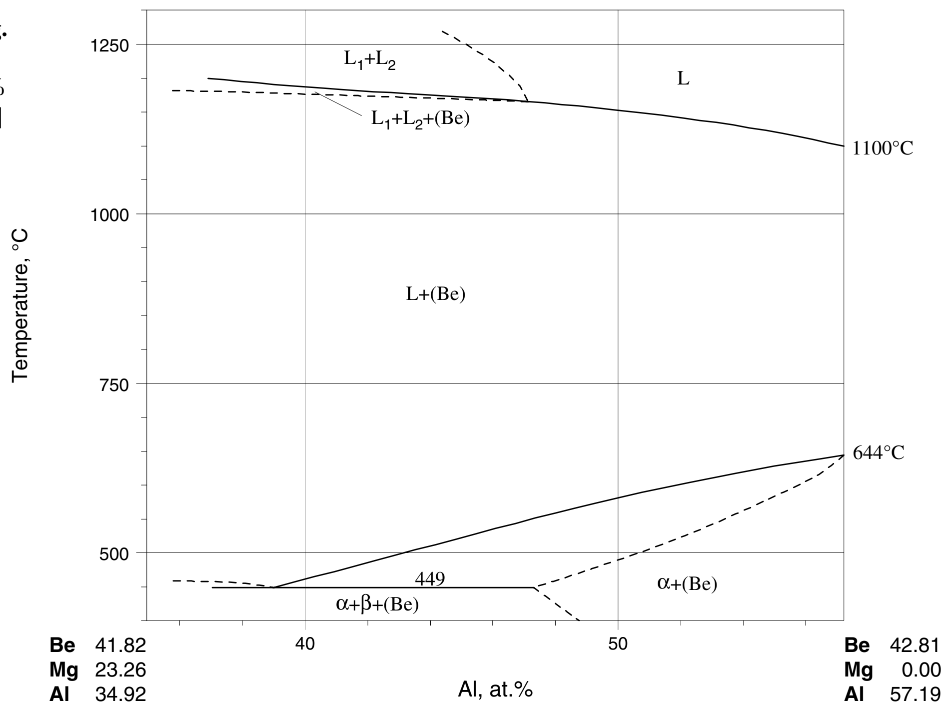

Fig. 8: Al-Be-Mg. Partial vertical section at 0.6 mass% Be; after [1966Nag]