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Le scandium

Economie et gîtologie

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Géosciences pour une Terre durable
brgm

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Hocquard C. (2003) - Le scandium – Economie et gîtologie, Rapport BRGM-RP-52460-FR - 65 p. ; 1 Tabl. ; 2 Fig.

Synthèse

- Le scandium (Sc), allié à l'aluminium, améliore considérablement les propriétés mécaniques de ce métal au point de les rapprocher de celles du titane, mais pour un prix divisé par deux.

- Ce « **titane du pauvre** » est actuellement surtout utilisé pour des applications de "niche" comme certains articles de sport ou les lampes halogènes. Toutefois, son usage devrait croître rapidement avec le développement attendu de nouveaux alliages complexes Al/Sc/X pour **l'industrie aéronautique**. Cette **évolution de la demande** aurait un impact radical sur le besoin d'identification de nouvelles ressources.

- La consommation mondiale de scandium est encore infime, de l'ordre de **2 t/an**.

- La production actuelle de scandium provient majoritairement de **Chine** et d'**Ukraine** (le scandium est récupéré en sous-produit de "stockpiles" de minerai de la mine de fer maintenant arrêtée de Zhovty Vody). Des capacités existeraient également au Kazakhstan et en Russie. Il n'y a aucune production occidentale.

- Le prix de l'oxyde Sc_2O_3 est élevé et, de plus, varie fortement (de 1 à 6) selon le degré de pureté et les quantités négociées (g ou kg). La commercialisation se fait essentiellement par l'intermédiaire de quelques **traders spécialisés.**

- Le scandium est si **dispersé** dans la nature qu'il ne forme pas de gisement primaire exploitable. Il est récupéré uniquement en **sous-produit** d'autres substances. Il est également **camouflé** dans nombre d'espèces minérales, associé à d'autres éléments comme la fluorine, le titane, les terres rares-yttrium, le phosphate, dans les gisements d'uranium, de niobium-tantale, d'étain-tungstène, de molybdène, etc. Les types de gisements correspondant sont le plus souvent de type résiduel, qu'ils soient hydrothermaux-magmatiques (pegmatites, etc.), ou sédimentaires (latérites sur roches mafiques) phosphates. Par ailleurs, on note l'intérêt des gisements anthropiques (résidus miniers issus de l'exploitation de gisements de fluorine, de porphyres à molybdène, résidus de traitement métallurgiques issus de la lixiviation de l'uranium).

- Pour l'analyse économique des occurrences de scandium, **trois facteurs déterminants** sont à considérer : la teneur moyenne du gisement, le pourcentage et la teneur en Sc du mineral porteur principal, l'extraction métallurgique.
  - **La teneur moyenne** : lorsque le scandium est réparti uniformément dans le gisement considéré (boues rouges de bauxite, limonites nickelifères etc.) ;
  - **La teneur du minéral porteur principal et son abondance** dans le gisement (tailings de Climax) : dans ce cas, on peut obtenir un minerai de scandium par simple concentration physique ;

- **L'extraction métallurgique** : dans les gisements où le scandium est adsorbé sur les argiles (latérites nickelifères, boues rouges), l'extraction par lixiviation acide ne donne que des taux de récupérations très faibles, à moins d'envisager des procédés, comme la mise en solution totale, dont les coûts sont prohibitifs.

- **La thortvéitite** est le principal minéral de scandium. Il se touve dans les pegmatites qui forment le plus souvent de gisements de très petites tailles et difficilement mécanisable. De plus sa **radioactivité** est une contrainte environnementale lourde.

- L'économie des futurs projets dépend pour beaucoup de l'identification des phases minéralogiques porteuses du Sc (**spéciation**) et des **procédés métallurgiques** d'extraction du métal.

- Il existe plusieurs **gisements secondaires** identifiés, en particulier **anthropiques,** avec des teneurs moyennes souvent comprises entre 50 et 300 g/t Sc, mais il n'y a encore aucun projet d'exploitation annoncé. La recherche du Sc est peu fréquente, de sorte les gisements scandifères sont encore mal connus.

La plus grande incertitude réside dans l'augmentation de la demande de Sc dans les cinq prochaines années, en relation avec l'utilisation probable des nouveaux alliages Al-Sc par la filière aéronautique.

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C Hocquard, revisée Y. Deschamps

PRECONCENTRATIONS et CONCENTRATIONS PRIMAIRES												
Famille	**Plutonisme granitique peralumineux "spécialisé"**		**Plutonisme alcalin - peralcalin, carbonatites**		**Plutonisme basique**	**Concentrations hydrothermales**	**Concentrations sédimentaires**				**Concentrations supergènes**	
Typologie géologique	**Pegmatites granitiques**	**Granites "spécialisés" porphyry Sn-W Mo**	**Carbonatites**	**Métasomatites Na carbonates, Olympic Dam type, albitites**	**Gites Fe-Ti-V dans anorthosites, gabbros**	**Gites hydrothermaux périgranitiques**	**Grès et conglomérats uranifères**	**Phosphorites fossiles et océaniques**	**Combustibles fossiles : charbons, bitumes, pétrole**	**Minerais Fe phosphatés et exhalatifs-sédimentaires**	**Latérites sur ultrabasites, bauxites**	**Placers (Ti-Zr, Sn-W, ..)**
Production	Ancienne	Projets	Projets	Actuelle	Potentiel	Projets	Actuelle					
Eléments associés	Ta, REE, W, Sn	Sn, W, Nb-Ta, Mo	Nb, REE, Zr, P	Fe, V, U, REE (Y)	Fe, Ti, V, P	W, U, CaF2	U, V	P, REE, U, Ga	V, Mo, Nb, Ni, Cr	Fe, P	Ni-Co, Al, Ga, Ti	Ti, Zr, REE, U, Sn
Porteurs Sc	**Thortveitite, Sc ixiolite, Sc columbo-tantalite**	**Wolframite, cassitérite, rutile Ta-Nb**	**Monazite, rhabdophane Sc columbite**	**Oxydes Fe ? Cr-V davidite**	**Ti-magnétite V-Sc ; ilménite**	**Davidite, wolframite, thortveitite**	**Vanadates U, davidite, brannérite**	**Prétulite, fluorapatite**	**Sorption sur matière organique**	**Prétulite, zircon Sc**	**Sorption sur argiles**, oxydes hydratés Fe-Al	**Zircon, monazite, ilménite, rutile**
Radio-activité	**Elevée**	Variable	**Elevée**	**Elevée**	Faible	Variable	**Elevée**	Variable	Faible	Faible	Faible	Variable
Teneur porteur principal	**3 - 18 % Sc (conc.)**	**0,1 - 0,4 % Sc**	**0,6 - 1 % Sc**	nd	70 - 1500 ppm Sc	nd	200 - 500 ppm Sc	nd	nd	nd	nd	nd
Teneur moyenne	100 ppm Sc ?	10 - 200 ppm	15 - 70 ppm Sc	50 - 200 ppm Sc	20 - 30 ppm Sc	nd	< 10 ppm Sc	0,1 - 60 ppm Sc	5 - 30 ppm Sc	40 - 1000 ppm Sc	5 - 100 ppm Sc	20 - 1500 ppm Sc
Tonnage métal par gisement	Faible	**Moyen - élevé**	**Elevé**	**Moyen - élevé**	**Moyen - élevé ?**	Faible	**Elevé**	**Très élevé**	**Elevé**	**Moyen - élevé**	**Elevé**	**Moyen - élevé**
reconcent. Supergènes		-	Résiduel supergène : hydroth. basse T° (Koydor)	Métasomatose Na et carbonatation haute T° de BIF	-	-	-	Croûtes phosphates Al supergènes	-	Hydrothermal (PO4)	-	-
SOURCES ANTHROPIQUES DERIVEES												
Source Sc		**Scories** W, Sn, Ta; **tailings** à rutile Sc			Concentrés Ti-magnétite	**Tailings** à fluorine - thortveitite	**Tailings** résidus hydrométallurgie U	Wet-process production of H3PO4	**Cendres** combustion (fly ash)		**Boues rouges** procédé Bayer	Scories ?
Teneur moyenne		100-900 ppm Sc (conc. W); Rutile Sc Climax : 1000 - 2300 ppm Sc			nd	nd	460 - 1800 ppm Sc	5 ppm Sc dans H3PO4	5 - 1000 ppm Sc (ash)		jusqué 300 ppm Sc	

1. Economie

1.1. PRODUCTION ET PRODUITS

La production récente provient de la Chine et de la CEI (Kazakhstan, Ukraine, et Russie). Il n'est pas exploité dans les pays occidentaux. En revanche, plusieurs sociétés purifient du Sc_2O_3 aux Etats-Unis (Mead-Colorado, Urbana-Illinois et Knoxville-Tennessee).

Selon Jostein Røyset, la production mondiale de scandium (sous forme d'oxyde de scandium, Sc_2O_3) **n'excèderait pas deux tonnes**. On peut donc parler d'un marché confidentiel. La production primaire (Chine, Ukraine[1]) est estimée à 400 kg, la différence provenant de déstockage des pays de la CEI (Ukraine, Russie). Quant à la production de scandium métal, elle serait < 10 kg...

Il existerait (non contrôlé) trois centres de production de scandium : l'un est lié aux terres rares chinoises de Bayan Obo (II.6), l'autre à l'apatite de Kola[2] en Russie, et le troisième à Zhovti Vody (Zheltye Voda) en Ukraine (II.6).

En raison de ses très faibles concentrations, le scandium est exclusivement un sous-produit issu de diverses sources : minerais primaires (pegmatites) et secondaires (résidus miniers). Le détail des productions n'est pas connu.

- Pegmatites à thortveïtite (silicate de scandium-yttrium).
- Résidus de traitement des minerais d'uranium.
- Résidus de traitement de minerais de tungstène.
- Sous-produit du traitement du minerai de fer de Zheltye Voda (Ukraine).

1.2. RECYCLAGE

Le scandium n'est pas recyclé.

1.3. STOCK

Il n'existe pas de stock de scandium au DLA. Les stocks en CEI sont inconnus.

[1] A Zheltye Voda, la production se poursuivrait à partir de stocks de minerais de fer encore disponibles en surface.
[2] Les terres rares cériques (1%) sont récupérées à 80-90 % après attaque acide des phosphogypses résiduels.

1.4. R&D MATERIAUX

La recherche sur les matériaux montre un engouement récent pour les alliages scandium-aluminum (Al-Sc), et les publications récentes (annexe) foisonnent.

Depuis les travaux de **Ashurst** Technology Corporation Limited (Ireland), et la conférence Scandium 94 à Moscou, on sait que l'ajout de scandium à l'aluminium permet d'améliorer considérablement les propriétés mécaniques de ce dernier. Dans les alliages Al\Sc, le Scandium induit une cristallisation plus fine (inhibiteur de la cristallisation), et augmente à la fois la résistance à la fatigue et la dureté de l'aluminium. Les recherches sur ces alliages ont débuté dans les années 70 en ex-URSS. La recherche sur les alliages avec Sc est intense et touche également les alliages magnesium-scandium (Mg\Sc).

Le scandium améliore considérablement les propriétés mécaniques de l'aluminium, en :

- Diminuant la ductilité plastique à haute température (creeping).
- Réduisant la granulométrie tout en modifiant la texture des grains.
- Réduisant la microfissuration durant les soudures entre alliages d'aluminium.
- Acquérant des facultés de superplasticité.
- Inhibant la recristallisation lors du travail à froid de ces alliages.

Les références commerciales restent liées aux alliages Al/Sc russes dont 15 sont commercialisés. Il s'agit d'alliages binaires ou ternaires Al-Mg-Sc avec Sc, Zr, parfois aussi Ti, Mn, Li, terres rares, etc.

Al-Mg (1515, 1523, 1535, 1570, 1571)

1515 - 1 % Mg, + Sc, Zr, terres rares,
1523 - 2 % Mg,
1570 - 6 % Mg, + Sc, Zr, Mn, Be.
1571 - 6 % Mg. (fil de soudure Al-Zn-Mg-Sc).

Al-Zn-Mg : (1970, 1975, 1981, 1987)

1970 – rapport Zr/Mg de 2.6, 5 % Zn et 1,7 % Mg, + Cu, Sc, Zr et Ti.
1975 – proche de 1970, avec moins de Sc (0.07 % Sc)
1981 – proche du AA7012, 1 % Cu.
1987 – propriétés superplastiques.

Al-Mg-Li (1421, 1423, 1424)

1421 - 5 % Mg, 2 % Li, 0.15 % Sc, 0.17 % Zr.
1423 - 3.5 % Mg

Al-Cu-Li : 1460

1460 - 3 % Cu, 2 % Li, 0.1 % Sc, 0.1 % Zr.

On note l'existence d'un brevet français : J.P. Collin (1995), alliage d'aluminium à hautes teneurs en Scandium et procédé de fabrication.

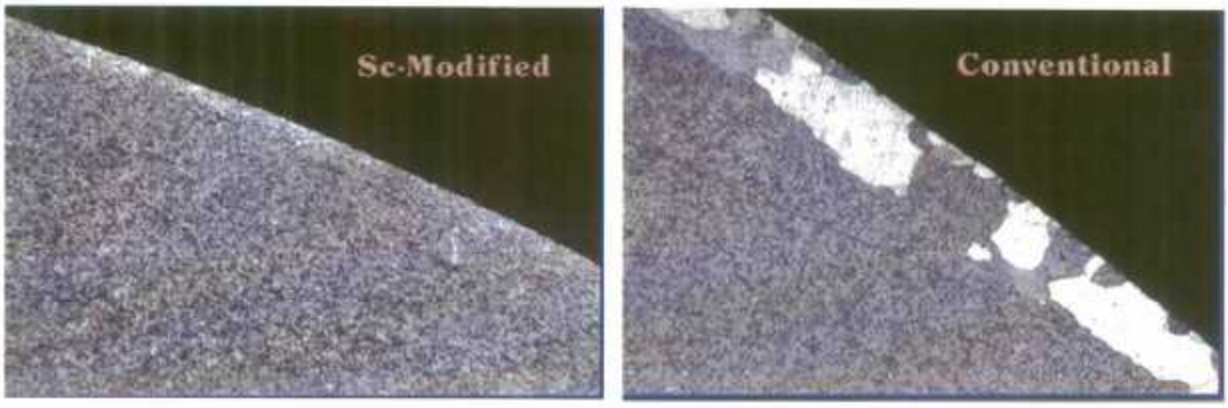

Fig. 1 : **Le scandium induit une réduction granulométrique de l'alliage Al-Sc, permettant un gain de 97 ksi (670 MPa) en résistance.** ***Bordure d'une batte de base-ball.***

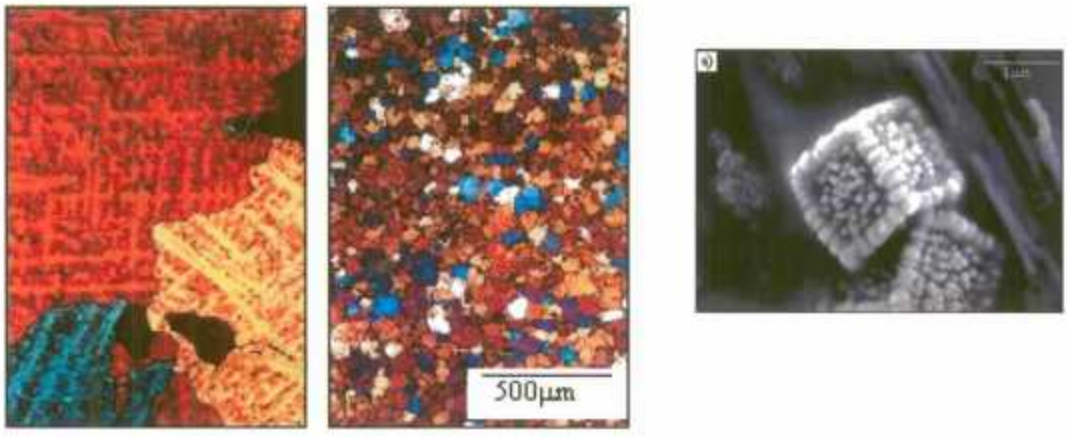

Fig. 2 : Scandium en tant que réducteur granulométrique : une concentration de 0,6 % Sc produit une diminution spectaculaire de la granulométrie tout en modifiant la microtexture de dendritique à polygonal (K. Hyde).

1.5. UTILISATIONS ACTUELLES

Le scandium est utilisé sous forme d'alliages scandium-aluminum (Al-Sc) pour leurs qualités de matériaux légers et très résistants ("**titane du pauvre**"). Il s'agit essentiellement d'applications de niche concernant des équipements de sport de haut de gamme, dont les quantités fabriquées sont très limitées.

➢ **Equipements de sport** : battes de base-ball (Easton, depuis 1997 et 5 autres sociétés depuis), raquettes de tennis (STX, depuis 1997), les cadres de bicyclette, crosses de revolvers (Smith & Wesson), etc.

➢ **Autres utilisations**

- Dans les lampes halogènes de haute intensité, il est utilisé, sous forme métallique ou d'iodure, pour donner une apparence de lumière naturelle.
- Lasers.
- Standards analytiques.
- Fil à souder (alliage d'aluminium, série 5025), réduit la micro fissuration.

1.6. R&D , NOUVELLES UTILISATIONS POTENTIELLES

La recherche sur les alliages d'aluminium-scandium (Al\Sc) foisonne et touche également les alliages magnésium-scandium (Mg\Sc). **Cette R&D est en grande partie coordonnée par les grands groupes industriels de la filière aéronautique :**

- Les premières applications aéronautiques ont été faites à l'époque de l'Union Soviétique pour les missiles et avions de chasse MIG.
- « Boeing s'intéresse à un nouvel alliage à base de scandium et d'aluminium pour l'industrie de l'aéronautique » La Tribune - 20/12/2001.
- Daimler Benz Aerospace étudie l'utilisation des alliages Al-Sc pour l'Airbus.

- Pratt & Whitney (juin 2003) annonce à la conférence ASM AeroMat de Dayton, avoir mis au point un nouvel alliage aluminium-scandium-X qui renforce la résistance de l'aluminium à température élevée, et qui trouverait des applications dans le domaine des fusées.

- Alcan International et BAe Systems financent les travaux de recherche sur les alliages Al-Sc à l'Université de Manchester - k.hyde@umist.ac.uk, *http://www2.umist.ac.uk/material/research/lap/kris hyde.htm*

1.6. SUBSTITUTION

Dans les applications telles que lampes et laser, le scandium n'est pas sujet à substitution. En revanche, il peut être concurrencé par le titane, d'autres alliages spéciaux d'aluminium et des composites à base de fibres de verre et de carbone.

Une nouveau type de matériau vient déjà concurrencer les alliages Al\Sc dans les articles de sport. Il s'agit de verres métalliques appelés BMG ("bulk metallic-glass alloys") de compositions complexes, incluant +/- Zr-Nb-Al-Ti-Cu-Ni-Be, et mis au point par l'équipe de W. L. Johnson du Caltech. La société Liquidmetal Technologies (Californie) commercialise des BMG pour les articles de sport : raquettes de tennis et canes de golf Heads. *http://www.matsci.caltech.edu/people/faculty/johnson_w.html*

1.7. DEMANDE

La demande a augmenté légèrement, mais le marché demeure minuscule. **La demande future dépend du passage à l'aéronautique des nouveaux alliages Al\Sc en cours d'étude**. Si tel est le cas, Il est probable que d'ici à 5 ans, la demande augmentera d'une manière qui ne pourra être qu'explosive compte tenu du point de départ...

1.8. PRIX

Les prix de l'oxyde (Sc_2O_3) sont élevés, mais l'alliage Al\Sc, dont la légèreté et les propriétés mécaniques sont voisines de celles du titane, est deux fois moins cher que le titane.

Les variations de prix s'expliquent par les quantités vendues (plus élevé pour un gramme que pour un kilo) et par le degré de pureté (de 1 à 6 fois !). Cependant, des traders proposeraient, via Internet (Annexe II), du scandium de 3 à 10 fois moins cher que les prix (relativement stables) indiqués par l'USGS ci-après.

	1997	1998	1999	2000	2001	2002
Per kilogram, oxide, 99.0 % purity	1,400	1,100	900	700	700	700
Per kilogram, oxide, 99.9 % purity	2,900	2,300	2,000	2,000	2,300	2,000
Per kilogram, oxide, 99.99 % purity	4,400	3,400	3,000	3,000	2,700	2,500
Per kilogram, oxide, 99.999 % purity	6,750	5,750	4,000	6,000	4,100	3,200
Per gram, metal	172	172	175	175	198	198
Per gram, scandium bromide, 99.99 % purity	90	90	91,80	91,80	94,60	94,60
Per gram, scandium chloride, 99.9 % purity	38,80	38,80	39,60	39,60	40,80	40,80
Per gram, scandium fluoride, 99.9 % purity	78,50	78,50	80,10	80,10	173	173
Per gram, scandium iodide, 99.999 % purity	148	148	151	151	156	156

http://minerals.usgs.gov/minerals/pubs/commodity/scandium/

2. Gîtologie et ressources de scandium[3]

Dans la croûte terrestre, le scandium est un constituant trace des minéraux ferromagnésiens (de 5 à 100 ppm équivalent Sc_2O_3 dans les amphibole-hornblende, pyroxène et biotite) des roches ignées basiques (basaltes et gabbros).

Dans la nature, les ressources en scandium sont très abondantes, mais excessivement dispersées et non concentrées. Le scandium est un métal rarement exprimé sous forme minérale spécifique, en revanche, il apparaît en solution solide dans plus de 100 minéraux[4]. Dans de très nombreux minerais, il n'est présent qu'en traces, sans enrichissement suffisant pour constituer des gisements primaires de scandium économiquement exploitables.

2.1. MINERAUX PRINCIPAUX DE SCANDIUM

Bazzite	$Be_3(Sc,Al)2Si_6O_{18}$	
Cascandite	$Ca(Sc,Fe{+}{+})Si_3O_8(OH)$	
Jervisite	$(Na,Ca,Fe{+}{+})(Sc,Mg,Fe{+}{+})Si_2O_6$	
Juonniite	$CaMgSc(PO_4)2(OH)\cdot4(H2O)$	11.58 % Sc
Kolbeckite	$ScPO_4\cdot2(H_2O)$	25.55 % Sc
Magbasite	$KBa(Al,Sc)(Mg,Fe{+}{+})6Si_6O_20F_2$	
Pretulite	$ScPO_4$	32.13 % Sc
Scandiobabingtonite	$Ca_2(Fe_2{+},Mn)ScSi_5O_{14}(OH)$	
Thortveitite	$(Sc,Y)2Si_2O_7$	
Titanowodginite	$Mn{+}{+}(Ti,Ta,Sc)2O_8$	

http://web.wt.net/~daba/Mineral/chem/Chem-Sc.html

2.2. TYPOLOGIE DES RESSOURCES DE SCANDIUM

Le scandium est un élément typiquement lithophile et résiduel ; que ce soit dans les processus magmatiques-hydrothermaux ou supergènes (latérites s.l.). Il est également étroitement associé au fluor, à la fois dans les processus magmatiques (carbonatites, gis. de fluorine) et sédimentaires (phosphates), il se fixe sur la matière organique (charbons), il est associé au titane (gisements de titano-magnétite, au rutile (minéral accessoire de porphyry Mo, etc.), et surtout aux terres rares (voisin de l'yttrium dans la table de Mendeléiev). On le retrouve aussi dans les gisements secondaires anthropiques dérivés de l'exploitation des gisements primaires : tailings (gis. de fluorine, de molybdène, d'uranium, d'étain), boues rouges issues du traitement des bauxites, altération supergène de carbonatites, cendres de charbon, etc.

[3] Scandia = Scandinavie
[4] Terres rares, wolframite-columbite, cassitérite, béryl, grenat, muscovite, minéraux phosphale.

A) Sc associé aux pegmatites à métaux rares : Ta, Nb, Ti, Y, U)

B) Sc est concentré par les processus supergènes (latérites Ni, bauxites).

D) Sc associé au fluor, à la fois dans les processus magmatiques (carbonatites, gis. de fluorine), et sédimentaires (phosphorites), fluor-apatite.

B) Sc associé à la matière organique (charbons, etc.).

C) Sc associé à l'uranium.

E) Sc concentré dans des minéraux comme le rutile, le xénotime (dans le réseau).

Réaliser une classification cohérente est particulièrement ardu pour cet élément à la fois peu concentré mais largement distribué dans la nature (les auteurs russes ont été les premiers à en montrer la complexité (Vlassov K.A., 1966, Borisenko L.F., 1989[5]).

2.3. OCCURRENCES IDENTIFIEES DE SCANDIUM

1. Pegmatites granitiques très fractionnées à thortveitite[6] à fluorine, columbo-tantalite.
2. Latérites sur roches mafiques (bauxites, nickel latéritique).
3. Phosphorites océaniques.
4. Charbons et cendres, pétrole.
5. Titanomagnétite à vanadium, titanium.
6. Carbonatites.
7. Sous-produit de la lixiviation in situ de gisement d'uranium.
8. Tailings avec rutile (et tantale) scandifère de porphyres à molybdène.
9. Tailings de gisements de fluorine.
10. Associé aux gisements d'étain-tungstène.

[5] - Borisenko L.F., 1989, Genetic types of scandium deposits , Inst. Mineral. Geochem. and Crystallochem. Rare Elements, Moscow, USSR Lithology and Mineral Resources. 23, 4, pp. 367-374. - Vlassov K. A., 1964, Geochemistry of rare elements, vol 1, pp. 156- 182, Traduction 1966, Monson, Israël .

[6] Thortvéitite, $Sc_2(Si_2O_7)$ silicate de scandium-yttrium, a été le premier minéral de scandium découvert en 1911 dans une pegmatite à Evje, en Norvège.

2.3.1. Pegmatites granitiques très fractionnées à thortveitite, fluorine, columbo-tantalite et autres éléments rares

- Région moldanubienne, Tchéquie.
- Rhodopes Centrales.
- Norvège : pegmatites à thortveitite de Heftetjern, Iveland-Evje Region et Tørdal, Telemark.
- Mineyama, Miyazu-Belt Kyoto, Japon.
- Région du lac Baïkal.
- Région de Shubar-Baytal, Est Kazakhstan.
- Madagascar : pegmatites de la région de Befanomo[7].

Pegmatites granitiques très fractionnées à thortveitite, colombo-tantalite et métaux rares

Dans les pegmatites de granites peralumineux en Tchéquie, le scandium s'accumule dans les minéraux « terminaux » oxydés colombo-tantalites (Nb-Ta), et sont étroitement liés au zircon et au xénotime. Dans les pegmatites très évoluées, il s'agit même de columbite-tantalite scandifère (1-3 % Sc). Il est moins abondant dans les pegmatites à beryl-columbite (0,81 % Sc). Dans les pegmatites complexes à lépidolite (Li), le contenu en Sc de la columbite est bas et erratique (0,44 % Sc). Certaines ixiolites (riches en Sn, Ta et W) peuvent aussi être scandifères (3 à 20 % Sc).

[7] J.P. Tutusaus, spécialiste Scandium, CSA consultants fax : 01 34 90 97 14

2.3.2. Latérites sur roches mafiques et alcalines (bauxites, nickel latéritique)

Le scandium est le plus souvent fortement fixé par la fraction argileuse (problèmes métallurgiques d'extraction).

- Ultramafites d'Ouzbékistan et Sud-Kirghizie.
- Croûtes d'altération supergène du massif de gabbro-norites de Volodarsk-Volyn.
- Scandium des boues rouges des bauxites du Guizhou, Chine.
- Scandium et terres rares des boues rouges des bauxites de Jamaïque.

Australie : latérites Ni-Co-(Sc) du New South Wales : Lake Innes et Syerston.

La junior australienne Jervois Mining NL (http://www.jervoismining.com.au/) détient deux projets de latérites nickélifères, Young et Lake Innes/Port Macquarie, en Nouvelle Galle du Sud (NSW).

➢ Young (NSW)

Ressources (0.8 % Ni cut-off): 58 millions tonnes à 0.99 % Ni, 0.07 %Co
Les analyses donnent une teneur moyenne de 41 g/t de scandium, qui serait récupéré en sous produit du nickel et du cobalt. Sur la base de cette teneur, la ressource dépasse 5 000 tonnes de Sc...

➢ Port Macquarie/Lake Innes (NSW)

La ressource du gisement de Lake Innes Nickel-Cobalt-(Scandium) totalise 12 Mt de minerai à 0,63 %Ni, 0,1 %Co, 40 ppm Sc (soit 500 t de scandium contenu). Le projet prévoit 1 Mt/an de minerai produisant 50-60 t/an de scandium. Il a très peu de chances d'aboutir, car les ressources Ni-Co sont insuffisantes et situées dans un parc national.

Ressource totale des 8 cibles sondées :

Métaux contenus	% Ni	% Co	**ppm Sc**	Tonnes	% Ni Equiv.	Ratio overburden/ Minerai
Nickel, Cobalt et Scandium	0,63	0,10	**40**	12,4 Mt	1,52	0,68/1

(% Ni Equivalent = % Ni + 5 x % Co plus 0,01 x ppmSc)

2.3.3. Phosphorites océaniques anciennes

Dans les phosphorites des marges continentales et des rides océaniques, la teneur en scandium va de 0,1 à 60 ppm. On note des valeurs faibles en scandium dans les nodules récents, mais de fortes valeurs dans des phosphorites de rides anciennes. L'enrichissement en Sc serait ainsi contrôlé par la surface de contact et le temps de contact avec l'eau de mer.

On constate également (Y. Moëlo et al., 2003), une concentration de scandium et de terres rares dans les phosphates sédimentaires recristallisés en fluorapatite (diagenèse). Cette diagenèse et/ou un faible métamorphisme forment également de la prétulite[8] et du xénotime (dont une génération tardive enrichie en scandium). On note la capacité de l'ion phosphate à fixer le scandium. Minéraux scandifères associés au xénotime disséminé dans certaines roches sédimentaires à faible métamorphisme.

2.3.4. Charbons (cendres volantes)

- Charbons du Kuznetsk (pétrole lourd du Turkménistan).

2.3.5. Titanomagnetite à vanadium, titanium, et scandium

- Mine de Kachkanar : déchets miniers de l'usine de valorisation de Svyatogor JSC Addres: 2, Sverdlov str., Kachkanar, Sverdlovsk region, Poste code: 624356 Russia, Fax: (34341)2-16-50 Director: Valeriy Borisovich Molchanov Director.

2.3.6. Carbonatites (et lignée associée de type Bayan Obo)

- Sous-produit du fer et terres rares à Bayan Obo (Chine) ainsi que Zheltye Voda, Krivoï Rog (Ukraine).
- Fluorapatite du massif de Kovdor, Peninsule de Kola[9].
- Carbonatite altérée du massif de Tomtor, Sibérie.
- Terres rares et scandium à Kumir dans le Gorny Altaï.
- Carbonatite de Mabounié
- Carbonatite de Fen (Nb, P et Fe) en Norvège

[8] Structure de zircon, phosphale de Sc (Sc,Y,TR) PO_4 est l'analogue Sc-dominant du xenotime-(Y). Il a élé decouvert en Autriche dans des filons de quarts de micaschistes des montagnes de Pretul, Styria, Austria. Ce mineral. Il est associé à la fluorapatite, chlorapatite, quartz, clinochlore, florencite-(Ce), xenotime-(Y), rutile.

[9] Le producteur russe AgroChimExport (Phosforchim) vend du scandium.

- **La "carbonatite" Fe\Sc\U\V\Zr de type Bayan Obo de Zhovti (Zheltye) Vody en Ukraine**

Ashurst Technology Ltd était une société nord américaine spécialisée dans les alliages aluminium-scandium, et qui possédait 34 % de la mine de fer de Zheltye Vody. Ashurst a levé 20 MUSD en bourse pour poursuivre ses recherches mais, pour se protéger de l'inflation, les a placés dans un fond de placement qui a fait faillite. Ashurst ne s'en est pas remis[10].

Zheltye Vody est situé dans le précambrien du Krivoï Rog. Le gisement de fer dont l'exploitation a atteint la profondeur de 1 000 m n'est plus exploité. Ses réserves initiales étaient de 7 Mt à 105 g/t Sc (soit environ 700 t de scandium contenu). Le scandium est récupéré comme sous-produit du fer. La production se poursuivrait à partir de stocks de minerais encore disponibles en surface.

Zheltye Vody est affecté d'un métasomatisme sodique et carbonatation de haute température au sein de BIF et d'arkose. En fait, on remarque que le gisement a une forme ovale avec une couronne de brèches carbonatées à magnétite-hématite-apatite avec une minéralisation disséminée de zircon, U, V, Sc, terres rares, pyrite. Le scandium Sc présente des teneurs allant de 50 à 200 ppm dans les métasomatites à aegirine-acmite. Des interprétations structurales/hydrothermales sont privilégiées, malgré une morphologie et une structure de type cheminée. **Cette description rappelle le type Bayan Obo - Olympic Dam.** De plus, on est en contexte de rift, en bordure de la faille de Krivoy Rog séparant archéen et Proterozoïque.

- **Carbonatites du massif de Kovdor, Russia**

La Yonaite est un minéral de scandium en sphérules de 0,8 mm dans les carbonatites dolomitiques du complexe alcalin-ultramafique de Kovdor (Kola Peninsula). Le Sc est associé à la monazite, le rutile, et à des films de Sc sur des phosphates.

- **La carbonatite altérée du massif alcalin-ultramafique à terres rares-Nb-Y-Sc de Tomtor (Sibérie)**

- **La carbonatite peralcaline de « Fen »**, près Ulefoss, à 110 km au SW d'Oslo (graben d'Oslo), contient de la thortvéitite (qui donne une teneur moyenne de l'ordre de 100 ppm Sc dans le faciès « rödberg » à fer-carbonate. On retrouve ici les caractéristiques des gisements Olympic Dam/Hernest Henry/Bayan Obo type :

  - Rift
  - Croûte continentale épaisse
  - Contexte général de caldera résurgente
  - Magmatisme alcalin peralcalin, I type
  - Mise en place à faible profondeur (volcanites et porphyry associés)

[10] La société, qui n'a pas été dissoute, maintiendrait un Centre de recherche à Baltimore, Maryland, USA, dans le cadre d'une JV avec le "Fransevich Institute for Problems of Materials Science (IPMS)" de Kiev, Ukraine.

- Très forte différentiation magmatique conduisant des syénites (et leurs équivalents volcaniques : trachytes) jusqu'aux granites, avec concentration des fluides magmatiques résiduels riches en fluor
- Altérations potassiques
- Collapse du système hydrothermal et invasion de fluides météoriques avec formation d'hématite
- Minéralisation à Cu-U-Au
- L'abondance en hématite : brèches à hematite d'affinités phréatomagmatiques (brèches et diatrèmes)

2.3.7. Sous-produit de la lixiviation in situ de gisements d'uranium

Sc est associé aux gisements d'uranium de Beshkak & Kanzhugan (Kazakhstan).

2.3.8. Tailings avec rutile scandifère des porphyres molybdiques de Climax et Henderson (Colorado)

Le rutile et la monazite sont très abondants dans les tailings des porphyres Mo de Climax et Henderson molybdenum mines. Leur récupération par séparation magnétique Frantz est aisée : 90 % du rutile est séparé. Le rutile[11] montre de fortes teneurs en niobium, tantale avec quelques dizaines de % de scandium. La composition moyenne des tailings est :

- 15,27 % Nb, 1,19 % Ta, et 0,23 % Sc à Climax.
- 16,59 % Nb, 2,48 % Ta, et 0,10 % Sc à Henderson.

2.3.9. Tailings de gisement de fluorine

Tailings à thortvéïtite de la mine de fluorine de Crystal Mountain (Montana), exploitée de 1952 à 1971.

2.3.10. Gisements d'étain-tungstène

- Chine (Provinces de Jiangxi, Guangxi, Guangdong, Fujian, et Zhejian).
- Le scandium est associé aux minerais d'étain-tungstène de Sikhote Alin (Russie).

[11] La récupération du Sc, du Nb, et du Ta donne une valeur de 15 $lb/rutile, comparé à 0,25 $lb/rutile ordinaire de sable de plage.

Annexes

Annexe 1

Commercialisation du Scandium

Il existe plusieurs sites internet qui commercialisent/utilisent du Sc ou des alliages Al-Sc :

- Aldrich APL, Urbana, Illinois (pour lampes halogène).
- Ames Laboratory de l'Iowa State University.
- Arris International Corporation.
- Ashurst Technology Ltd.
- Boulder Scientific Company (Mead, Californie).
- Changsha Rare Earth Technology Co., Ltd.
- GMH Jost-Hinrich Stachow GmbH Metallhandel.
- Gosincor (State Investment Corporation en Russie).
- HEFA Rare Earth au Canada, filiale de "Inner Mongolia HEFA Rare Earth Seience & Technology Development Co., Ltd." à Baotou, Chine.
- Tianjiao International, le plus gros fabricant de Terres Rares chinois.
- Metal Pacific Corporation (Chine).
- Meldform Group.
- Mitsubishi Materials.
- Reade Advanced Materials.
- Sausville Chemicals (Knoxville, Tennessee, en stand by).
- Stanford Materials Company.
- Stigma LTD, trader de produits de Russie.
- TTE Metals.
- AgroChimExport ("Phosphorchim") Russie.
- le trader Semidex-Riga.

a) Alliages spéciaux

- http://www.americanelements.com/al.html
- Stanford Materials Corporation http://www.stanfordmaterials.com/sc.html
  - 99,9 % Sc : US$ 7 100/kg.
  - 50 kg de Al-2 %Sc, équivalent à 1 kg Sc, vaut US$ 8 700.

b) Sociétés avec des informations sur les propriétés des alliages Al-Sc

- Easton, équipements de sport, cadre de bicyclette.
- Hodaka, Taiwan, cadres de bicyclettes.
- Smith&Wesson, armes.

c) Données économiques – géologie

U.S. Geological Survey http://minerals.usgs.gov/minerals/pubs/commodity/scandium/820303.pdf

Scandium 2003 : Symposium international sur la géologie et la minéralogie du scandium organisé en Norvège par l'University of Oslo, du 16 to 22 August 2003 (Natural History Museums and Botanical Garden).

http://www.home.no/al-sc/confers.html : portail des congrès concernan t Sc
2003 TMS Annual Meeting in San Diego, Californnir, mars 2003.

http://home.no/al-sc/
Rare Earth Information Center at Ames Laboratory
http://minerals.usgs.gov/minerals/pubs/commodity/scandium/

Hyde K., Dynamic Grain Growth of Model Aluminium Alloys: The Addition of Sc to Aerospace Casting Alloys A201 and A357.
http://www2.umist.ac.uk/material/research/lap/kris hyde.htm

Annexe 2

Bibliographie

Base GEOREF : interrogation sur SCANDIUM

Enregistrement 1 de 62 - GeoRef Disc 5: 1997-2001/05

Translated Title: Uranium-bearing multi-element exogene epigenetic deposits; formation conditions and sources of metals recovered by underground leaching.
AU: Laverov-N-P; Lisitsin-A-K; Solodov-I-N.

Enregistrement 3 de 62 - GeoRef Disc 5: 1997-2001/05

TI: The formation of scandium minerals as an example of the role of complexes in the geochemistry of rare earths and HFS elements.
AU: Gramaccioli-Carlo-Maria; Diella-Valeria; Demartin-Francesco.
AF: Universita di Milano, Dipartimento di Scienze della Terra, Milan, Italy.
SO: European Journal of Mineralogy. 12; 4, Pages 795-808. 2000.
PB: Schweizerbart'sche Verlagsbuchhandlung (Naegele u. Obermiller). Stuttgart, Federal Republic of Germany. 2000.
CP: Federal-Republic-of-Germany.
PY: 2000.

Enregistrement 6 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Genesis of Sc-bearing mineral associations of Kovdor Massif according to Sr isotope data.
AU: Liferovich-Ruslan; Gogol-Olga.
AF: Russian Academy of Sciences, Geological Institute, Apatity, Russian Federation.
BK: In: European Union of Geosciences conference abstracts; EUG 10.
BA: Anonymous.
SO: Journal of Conference Abstracts. 4; 1, Pages 296. 1999.
NT: Terra Abstracts, Vol. 11.
PB: Cambridge Publications. Cambridge, United Kingdom. 1999.
CP: United-Kingdom.
PY: 1999.
CN: European Union of Geosciences conference; EUG 10. Strasbourg, France. March 28-April 1, 1999.

Enregistrement 7 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Presence of scandium mineralization in granite pegmatites; mineralogical and geochemical criteria.
AU: Gordienko-V-V.
AF: Saint Petersburg State University, Saint Petersburg, Russian Federation.
SO: Transactions (Doklady) of the Russian Academy of Sciences. Earth Science Sections. 357; 8, Pages 1248-1252. 1997.
PB: MAIK Nauka/Interperiodica. Moscow, Russian Federation. 1997.
CP: Russian-Federation.
PY: 1997.

Enregistrement 13 de 62 - GeoRef Disc 5: 1997-2001/05

TI: REE-bearing minerals in Ohro granitic pegmatite of Mineyama, Kyoto, Japan.
AU: Sugimoto-A; Kimata-M; Nishida-N; Hatta-T; Fujiwara-T; Hori-H.
BK: In: Abstracts of the annual meeting of the Mineralogical Society of Japan, 1999.
SO: Mineralogical Journal. 22; 1, Pages 32. 2000.
PB: Nippon Kobutsu Gakkai; Japan Publications Trading Co., Ltd.. Tokyo, Japan. 2000.
CP: Japan.
PY: 2000.
CN: Annual meeting of the Mineralogical Society of Japan. Tokyo, Japan. Sept. 23-26, 1999.

Enregistrement 14 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Sorbtsiya skandiya i RZE kak prichina ikh nakopleniya v korakh vyvetrivaniya
Translated Title: Scandium and REE sorption as cause of their accumulation in weathering crusts.
AU: Stryapkov-A-V.
AF: Karagandinskiy Gosudarstvennyy Universitet, Karaganda, Kazakhstan.

SO: Geokhimiya. 1997; 9, Pages 930-936. 1997.
PB: MAIK Nauka. Moscow, Russian Federation. 1997.
CP: Russian-Federation.
PY: 1997.

Enregistrement 16 de 62 - GeoRef Disc 5: 1997-2001/05

BK: Rudnyye resursy i ikh razmeshcheniye po geoepokham; redkiye metally; tantal, niobiy, skandiy, redkiye zemli, tsirkoniy, gafniy; (Spravochnoye posobiye).
Translated Title: Ore resources and localization according to geoepochs; rare metals; tantalum, niobium, scandium, rare earths, zirconium, and hafnium; reference book.
BA: Belyayev-K-D; Ganeyev-I-G; Chayka-V-D; Chernov-V-D.
BF: Noril'skiy Gorno-Obogatitel'nyy Kombinat, Norilsk, Russian Federation; Rossiyskaya Akademiya; Nauk, Russian Federation; Gosudarstvennyy Geologicheskiy Muzey im. V. I. Vernadskogo, Russian Federation; Akademiya Mineral'nykh Resursov, Russian Federation.
PB: Nedra. Moscow, Russian Federation. Pages: 175. 1996.
CP: Russian-Federation.
PY: 1996.

Enregistrement 19 de 62 - GeoRef Disc 5: 1997-2001/05

TI: A unique scandium mineralization in Kovdor Massif, Russia.
AU: Liferovich-Ruslan; Subbotin-Viktor; Pakhomovsky-Yakov; Lyalina-Margarita.
AF: Russian Academy of Sciences, Geological Institute, Apatity, Russian Federation.
BK: In: European Union of Geosciences conference abstracts; EUG 10.
BA: Anonymous.
SO: Journal of Conference Abstracts. 4; 1, Pages 496. 1999.
NT: Terra Abstracts, Vol. 11.
PB: Cambridge Publications. Cambridge, United Kingdom. 1999.
CP: United-Kingdom.
PY: 1999.
CN: European Union of Geosciences conference; EUG 10. Strasbourg, France. Mar. 28-Apr. 1, 1999.

Enregistrement 24 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Scandium in the crust of the weathering and redeposition products of ultrabasic rocks, Uzbekistan and South Kirgizia.
AU: Koldaev-Alexandr-(Koldayev-Aleksandr); Kotov-Nikolay; Flizian-Elena; Osinskaya-Nadegda; Orestova-Irina.
AF: Science Academy, Institute of Geology and Geophysics, Tashkent, Uzbekistan.
BK: In: 30th international geological congress; abstracts.
BA: Anonymous.
SO: International Geological Congress, Abstracts = Congres Geologique International, Resumes. 30, Vol. 3; Pages 77. 1996.
PB: [International Geological Congress]. [location varies], International. 1996.
RP: IGC (International Geological Congress).
CP: International.
PY: 1996.
CN: 30th international geological congress. Beijing, China. Aug. 4-14, 1996.

Enregistrement 25 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Some characteristics of scandium in bauxite and red mud from central Guizhou.
AU: Xiao-Jinkai; Lei-Jianquan; Xia-Xiang.
AF: Chinese Academy of Sciences, Institute of Geochemistry, Guiyang.
SO: Kuang Wu Xue Bao = Acta Mineralogica Sinica. 14; 4, Pages 388-393. 1994.
PB: Academia Sinica. Guiyang, China. 1994.
CP: China.
PY: 1994.
LA: Chinese.
LS: English.

Enregistrement 28 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Modelirovaniye migralsii skandiya i vanadiya v svyazi s ribekitizatsiyey kummingtonilsoderzhashchikh zheleznykh rud Pervomayskogo mestorozhdeniya (Krivorozhskiy bassesyn).
Translated Title: Modelling of scandium and vanadium migration as a result of riebeckitization of cummingtonite-containing iron ores of the Pervomayskoye Deposit; Krivoy Rog Basin.
AU: Yevtekhov-V-D; Kharitonov-V-N.
SO: Mineralogicheskiy Zhurnal. 21; 1, Pages 60-65. 1999.
PB: Natsional'naya Akademiya Nauk Ukrainy, Institut Geokhimii, Mineralogii i Rudoobrazovaniya. Kiev, Ukraine. 1999.
CP: Ukraine.
PY: 1999.
LA: Russian.
LS: English.

Enregistrement 30 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Determination of scandium, yttrium and rare earth elements in rocks by high resolution inductively coupled plasma-mass spectrometry.
AU: Robinson-Philip; Townsend-Ashley-T; Yu-Zongshou; Muenker-Carsten.
AF: University of Tasmania, School of Earth Sciences, Tasmania, Australia.
SO: Geostandards Newsletter. 23; 1, Pages 31-46. 1999.
PB: Association Nationale de la Recherche Technique. Paris, France. 1999.
CP: France.
PY: 1999.
LA: English.

Enregistrement 31 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Scandium and lanthanum in oceanic phosphorites.
AU: Baturin-G-N.
AF: Russian Academy of Sciences, Shirshov Institute of Oceanology, Moscow, Russian Federation.
SO: Oceanology. 39; 3, Pages 391-400. 1999.
PB: MAIK Nauka/Interperiodica. Birmingham, AL, United States. 1999.
CP: United-States.
PY: 1999.

Enregistrement 32 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Pretulite, ScPO (sub 4); a new scandium mineral from the Styrian and Lower Austrian lazulite occurrences, Austria.
AU: Bernhard-Franz; Walter-Franz; Ettinger-Karl; Taucher-Josef; Mereiter-Kurt.
AF: Karl-Franzens-Universitaet Graz, Institut fuer Mineralogie-Kristallographie und Petrologie, Graz, Austria.
SO: American Mineralogist. 83; 5-6, Pages 625-630. 1998.
PB: Mineralogical Society of America. Washington, DC, United States. 1998.
CP: United-States.
PY: 1998.

Enregistrement 37 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Scandium in columbite-group minerals from LCT pegmatites in the Moldanubicum, Czech Republic.
AU: Novak-Milan; Cerny-Petr.
AF: Moravian Museum, Department of Mineralogy and Petrology, Brno, Czech Republic.
SO: Krystalinikum. 24; Pages 73-89. 1998.
PB: Ceskoslovenska Akademie Ved. Prague, Czech Republic. 1998.
CP: Czech-Republic.
PY: 1998.

Enregistrement 38 de 62 - GeoRef Disc 5: 1997-2001/05

TI: A new type of scandium mineralization in phoscorites and carbonatites of the Kovdor Massif, Russia.
AU: Liferovich-Ruslan-P; Subbotin-Viktor-V; Pakhomovsky-Yakov-A; Lyalina-Margarita-F.
AF: Russian Academy of Sciences, Kola Science Center, Geological Institute, Apatity, Russian Federation.
SO: The Canadian Mineralogist. 36, Part 4; Pages 971-980. 1998.

PB: Mineralogical Association of Canada. Ottawa, ON, Canada. 1998.
CP: Canada.
PY: 1998.

Enregistrement 39 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Scandium substitution in columbite-group minerals and ixiolite.
AU: Wise-Michael-A; Cerny-Petr; Falster-Alexander-U.
AF: Smithsonian Institution, Department of Mineral Sciences, Washington, DC, United States.
BK: In: Granitic pegmatites; the Cerny-Foord volume.
BA: Anderson-Alan-J (prefacer); Simmons-William-B Jr. (prefacer); Groat-Lee-A (prefacer).
SO: The Canadian Mineralogist. 36, Part 2; Pages 673-680. 1998.
PB: Mineralogical Association of Canada. Ottawa, ON, Canada. 1998.
CP: Canada.
PY: 1998.

Enregistrement 40 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Determination of yttrium, scandium and other rare earth elements in uranium-rich geological materials by ICP-AES.
AU: Ramanaiah-G-V.
AF: Department of Atomic Energy, Atomic Minerals Division, Begumpet, India
SO: Talanta (Oxford). 46; 4, Pages 533-540. 1998.
PB: Elsevier. Oxford, United Kingdom. 1998.
CP: United-Kingdom.
PY: 1998.

Enregistrement 41 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Metalliferous coals; utilization prospects and problems.
AU: Seredin-Vladimir-V; Shpirt-Michail-Y.
AF: Russian Academy of Sciences, IGEM, Moscow, Russian Federation.
BK: In: Geological Society of America, 1998 annual meeting.
BA: Anonymous.
SO: Abstracts with Programs - Geological Society of America. 30; 7, Pages 342. 1998.
PB: Geological Society of America (GSA). Boulder, CO, United States. 1998.
CP: United-States.
PY: 1998.
CN: Geological Society of America, 1998 annual meeting. Toronto, ON, Canada. Oct. 26-29, 1998.

Enregistrement 46 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Rare earth elements and scandium in Kuznetsk Basin coals.
AU: Arbuzov-S-I; Ershov-V-V-(Yershov-V-V); Potseluev-A-A-(Potseluyev-A-A); Rikhvanov-L-P; Sovelov-V-M.
AF: Tomsk Politechnical University, Department of Economic Geology and Geochemistry of Rare Elements, Tomsk, Russian Federation.
SO: Lithology and Mineral Resources. 32; 3, Pages 275-285. 1997.
PB: Consultants Bureau. New York, NY, United States. 1997.
CP: United-States.
PY: 1997.
LA: English.

Enregistrement 56 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Enait; novyy mineral skandiya iz kal'tsit-dolomitovykh karbonatitov Kovdorskogo massiva.
Translated Title: Yonaite; a new scandium mineral from dolomite-bearing carbonatites of the Kovdor Massif.
AU: Liferovich-R-P; Yakovenchuk-V-N; Pakhomovskiy-Ya-A; Bogdanova-A-N; Britvin-S-N.
AF: Rossiyskaya Akademiya Nauk, Kol'skiy Nauchnyy Tsentr, Geologicheskiy Institut, Apatity, Russian Federation.
SO: Zapiski Vserossiyskogo Mineralogicheskogo Obshchestva = Proceedings of the Russian Mineralogical Society. 126; 4, Pages 80-88. 1997.
PB: Nauka. St. Petersburg, Russian Federation. 1997.
CP: Russian-Federation.

PY: 1997.
LA: Russian.
LS: English.

Enregistrement 60 de 62 - GeoRef Disc 5: 1997-2001/05

BK: Kompleksnoye ispol'zovaniye titanomagnetitovykh rud.
Translated Title: Diversification in use of titanomagnetite ores.
BA: Borisenko-L-F; Delitsyn-L-M; Polubabkin-V-A; Uskov-E-D.
BF: Institut Mineralogii, Geokhimii i Kristallokhimii Redkikh Ehlementov, Moscow, Russian Federation; Rossiyskaya Akademiya Nauk, Russian Federation; Kachkanarskiy Gorno-Obogatitel'nyy Kombinat, Russian Federation.
SO: Laboratornyye i Tekhnologicheskiye Issledovaniya Obogashcheniye Mineral'nogo Syr'ya. 1997; 2, 1997.
PB: VIEMS. Moscow, Russian Federation. Pages: 65. 1997.
CP: Russian-Federation.
PY: 1997.
LA: Russian.

Enregistrement 61 de 62 - GeoRef Disc 5: 1997-2001/05

TI: Pirokhlor v kore vyvetrivaniya.
Translated Title: Pyrochlore in weathering crust.
AU: Lapin-A-V; Semenov-Ye-I; Lenaro-S; Ivanukh-V.
AF: Rossiyskaya Akademiya Nauk, Institut Mineralogii, Geokhimii i Kristallokhimii Redkikh Elementov, RUS, Russian Federation.
SO: Otechestvennaya Geologiya. 1997; 4, Pages 16-21. 1997.
PB: Izdatel'stvo Nedra. Moscow, Russian Federation. 1997.
CP: Russian-Federation.
PY: 1997.
LA: Russian.

Enregistrement 9 de 91 - GeoRef Disc 4: 1993-1996

TI: Concentrations of rare earth elements in some Australian soils.
AU: Diatloff-E; Asher-C-J; Smith-F-W.
AF: CSIRO Division of Tropical and Pastures, Cunningham Laboratory, St. Lucia, Queensl., Australia.
SO: Australian Journal of Soil Research. 34; 5, Pages 735-747. 1996.
PB: CSIRO (Commonwealth Scientific and Industrial Research Organisation. Melbourne, Victoria, Australia. 1996.
CP: Australia.
PY: 1996.
LA: English.
DE: Aqueous-solutions; Australasia-; Australia-; cerium-; chemical-composition; geochemistry-; lanthanum-; metals-; New-South-Wales-Australia; pH-; phosphate-ion; Queensland-Australia; rare-earths; scandium-; soils-; solubility-.

Enregistrement 10 de 91 - GeoRef Disc 4: 1993-1996

TI: Characterizing coal beds in western Kentucky with the Al-La-Sc coherent triad.
AU: Chyi-L-L; Medlin-J-H.
AF: University of Akron, Department of Geology, Akron, OH, United States.
BK: In: Coalification and coal petrology.
BA: Chyi-L-L (editor); Medlin-J-H (editor); Coleman-S-L (editor).
SO: International Journal of Coal Geology. 30; 4, Pages 349-359. 1996.
NT: Special issue.
PB: Elsevier. Amsterdam, International. 1996.
RP: IGC (International Geological Congress | USGSOP (Non-USGS publications with USGS authors).
CP: International.
PY: 1996.
CN: 29th international geological congress. Kyoto, Japan. Sept. 2, 1992.

Enregistrement 11 de 91 - GeoRef Disc 4: 1993-1996

Enregistrement 13 de 91 - GeoRef Disc 4: 1993-1996

TI: Scandium in rare-metal granites of the central Sikhote Alin and the associated tin-tungsten ores.
AU: Rub-A-K; Rub-M-G; Chistyakov-N-I; Rub-I-A.
AF: Russian Academy of Sciences, Institute of Economic Geology, Petrography, Mineralogy and Geochemistry, Moscow, Russian Federation.
SO: Transactions (Doklady) of the Russian Academy of Sciences. Earth Science Sections. 343A; Pages 137-142. 1996.
PB: Scripta Publishing. Silver Spring, MD, United States. 1996.
CP: United-States.
PY: 1996.

Enregistrement 20 de 91 - GeoRef Disc 4: 1993-1996

TI: The Tomtor alkaline ultrabasic massif and related REE-Nb deposits, northern Siberia.
AU: Kravchenko-S-M; Pokrovsky-B-G.
AF: Russian Academy of Sciences, Institute of Ore Deposit Geology, Petrography, Mineralogy, and Geochemistry, Moscow, Russian Federation.
BK: In: A special issue devoted to the geology of rare metal deposits.
BA: Pollard-Peter-J (editor).
SO: Economic Geology and the Bulletin of the Society of Economic Geologists. 90; 3, Pages 676-689. 1995.
PB: Economic Geology Publishing Company. Lancaster, PA, United States. 1995.
RP: IGCP (International Geological Correlation Programme).
CP: United-States.
PY: 1995.

Enregistrement 30 de 91 - GeoRef Disc 4: 1993-1996

TI: Sveconorwegian pegmatites of south-central Norway and their geochemical relations in time and space.
AU: Juve-G; Bergstol-S.
AF: Norges Geologiske Undersokelse, Trondheim, Norway.
BK: In: Precambrian of Europe; stratigraphy, structure, evolution and mineralization.
BA: Glebovitsky-V-A (editor-Glebovitskiy-V-A); Kotov-A-B (editor).
SO: Meeting of European Geological Societies - Abstracts. 9; Pages 49. 1995.
PB: [publisher varies]. [location varies], International. 1995.
CP: International.
PY: 1995.
CN: MAEGS 9; Ninth meeting of the Association of European Geological Societies. St. Petersburg, Russian Federation. Sept. 4-15, 1995.

Enregistrement 31 de 91 - GeoRef Disc 4: 1993-1996

TI: Non-conventional scandium and vanadium resources in alkali metasomatic rocks of the Krivoy Rog Pre-Cambrian banded iron basin.
AU: Valeyev-O-K.
AF: Krivoy Rog Technical University, Krivoy Rog, Ukraine.
BK: In: Precambrian of Europe; stratigraphy, structure, evolution and mineralization
BA: Glebovitsky-V-A (editor-Glebovitskiy-V-A); Kotov-A-B (editor).
SO: Meeting of European Geological Societies - Abstracts. 9; Pages 123. 1995.
PB: [publisher varies]. [location varies], International. 1995.
CP: International.
PY: 1995.
CN: MAEGS 9; Ninth meeting of the Association of European Geological Societies. St. Petersburg, Russian Federation. Sept. 4-15, 1995.

Enregistrement 57 de 91 - GeoRef Disc 4: 1993-1996
TI: Mineralogiya kompleksnykn skandiy-vanadiy-zheleznykh rud Severnogo rayona Krivorozhskogo basseyna
Translated Title: Mineralogy of complex scandium, vanadium and iron ores from northern Krivoy Rog Basin.
AU: Yevtekhov-V-D.
SO: Mineralogicheskiy Zhurnal. 16; 5-6, Pages 37-45. 1994.
PB: Akademiya Nauk Ukrainy. Kiev, Ukraine. 1994.

CP: Ukraine.
PY: 1994.
LS: English; Ukrainian.

Enregistrement 71 de 91 - GeoRef Disc 4: 1993-1996

TI: Skandiy-redkozemel'noye rudoproyavleniye Kumir v Gornom Altaye.
Translated Title: Kumir rare earth-scandium ore occurrence in Gorny Altai.
AU: Yegorov-V-S; Kazakov-A-A; Kazantsev-V-V; Meshcherskiy-Yu-A; Ordynets-G-Ye.
SO: Izvestiya Vysshikh Uchebnykh Zavedeniy. Geologiya i Razvedka. 1993; 2, Pages 43-54. 1993.
PB: Ministerstvo Vysshego i Srednego Obrazovaniya. Moscow, Russian Federation. 1993.
CP: Russian-Federation.
PY: 1993.
LA: Russian.

Enregistrement 72 de 91 - GeoRef Disc 4: 1993-1996

TI: Novyye dannyye o prirode kontsentratsiy reniya i skandiya v plastovo-infil'tratsionnykh mestorozhdeniyakh urana.
Translated Title: New data on the nature of rhenium and scandium in infiltrational layers of uranium deposits.
AU: Vershkov-A-F; Krasnova-N-I.
SO: Izvestiya Vysshikh Uchebnykh Zavedeniy. Geologiya i Razvedka. 1993; 2, Pages 143-146. 1993.
PB: Ministerstvo Vysshego i Srednego Obrazovaniya. Moscow, Russian Federation. 1993.
CP: Russian-Federation.
PY: 1993.
LA: Russian.

Enregistrement 73 de 91 - GeoRef Disc 4: 1993-1996

TI: O metallonosnosti neftey Zapadnoy Turkmenii.
Translated Title: Metal-bearing oils in western Turkmenia.
AU: Mirzoyev-R-Kh; Gasanov-R-K; Kharitonov-V-M.
SO: Geologiya Nefti i Gaza. 1993; 5, Pages 43-46. 1993.
PB: "Nedra". Moscow, Russian Federation. 1993.
CP: Russian-Federation.
PY: 1993.
LA: Russian.
LS: English.

Enregistrement 82 de 91 - GeoRef Disc 4: 1993-1996

TI: Mineraly skandiya i perspektiva ikh otkrytiya v Ukraine.
Translated Title: Scandium minerals and prospects for discoveries in Ukraine.
AU: Pavlishin-V-I; Yevtekhov-V-D; Legkova-G-V; Kozak-S-A.
SO: Mineralogicheskiy Zhurnal. 15; 5, Pages 5-12. 1993.
PB: Akademiya Nauk Ukrainy. Kiev, Ukraine. 1993.
CP: Ukraine.
PY: 1993.
LA: Russian.
LS: English; Ukrainian.

Enregistrement 84 de 91 - GeoRef Disc 4: 1993-1996

TI: Perspektivy rasshireniya kompleksnosti ispol'zovaniya titanomagnetitovykh rud Kachkanarskogo tipa
Translated Title: Prospects of increasing the complexity of utilization of titanomagnetite ores of Kachkanar Mine.
AU: Borisenko-L-F; Uskov-Ye-D.
SO: Gornyy Zhurnal. 1993; 9-10, Pages 11-13. 1993.
PB: Izdatel'stvo Nedra. Moscow, Russian Federation. 1993.
CP: Russian-Federation.
PY: 1993.
LA: Russian.

Enregistrement 91 de 91 - GeoRef Disc 4: 1993-1996

TI: A possible new commercial source of rare earth elements.
AU: Lisitsin-A-K; Zichenkov-L-Ch; Solodov-I-N.
AF: USSR Academy of Sciences, Institute of Economic Geology, Moscow, Russian Federation.
SO: Transactions (Doklady) of the Russian Academy of Sciences. Earth Science Sections. 316; Pages 241-245. 1993.
PB: Scripta Publishing. Silver Spring, MD, United States. 1993.
CP: United-States.
PY: 1993.

Enregistrement 12 de 152 - GeoRef Disc 3: 1985-1992.
TI: The Zhellorechensk vanadium-scandium deposit.
AU: Tarkhanov-A-V; Kulayev-A-R; Petrin-A-V; Kozyr-kov-V-D.
AF: All-Union Research Institute of Chemical Technology, Moscow, Russian Federation.
SO: International Geology Review. 34; 5, Pages 496-502. 1992.
PB: Winston & Son. Silver Spring, MD, United States. 1992.
CP: United-States.
PY: 1992.

Enregistrement 15 de 152 - GeoRef Disc 3: 1985-1992

BK: Magnetically recoverable rare-metal-rich rutile and monazite in ore and tailings of the Climax and Henderson molybdenum mines, Colorado.
BA: Xu-Yan.
CP: United-States.
PY: 1992.
DG: Master's.
DI: Purdue University. West Lafayette, IN, United States. Pages: 69. 1992.

Enregistrement 34 de 152 - GeoRef Disc 3: 1985-1992

TI: Behavior of scandium during rock laterization.
AU: Tenyakov-V-A; Edlin-M-G-(Yedlin-M-G); Miloslavskiy-O-A; Mamedov-V-I.
AF: All-Union Research Institute of Economic Geology, Moscow, Russian Federation.
SO: Transactions (Doklady) of the Russian Academy of Sciences. Earth Science Sections. 307; Pages 213-216. 1991.
PB: Scripta Publishing. Silver Spring, MD, United States. 1991.
CP: United-States.
PY: 1991.

Enregistrement 37 de 152 - GeoRef Disc 3: 1985-1992

TI: Scandium-rare earth-yttrium-niobium ores; a new economic resource.
AU: Kravchenko-S-M; Belyakov-A-Yu; Kubyshev-A-I; Tolstov-A-V.
AF: USSR Akad. Sci., Inst. Geol. Ore Deposits, Petrol., Mineral. and Geochem., Moscow, USSR.
SO: International Geology Review. 32; 3, Pages 280-284. 1990.
PB: Winston & Son. Silver Spring, MD, United States. 1990.
CP: United-States.
PY: 1990.

Enregistrement 47 de 152 - GeoRef Disc 3: 1985-1992

TI: Skandiyevo-redkozemel'no-ittriyevo-niobiyevyye rudy; novyy tip redkometal'nogo syr'ya.
Translated Title: Scandium, rare earth, yttrium and niobium ores; a new type of rare earth mineralization.
AU: Kravchenko-S-M; Belyakov-A-Yu; Kubyshev-A-I; Tolstov-A-V.
SO: Geologiya Rudnykh Mestorozhdeniy. 32; 1, Pages 105-109. 1990.
PB: Rossiyskaya Akademiya Nauk. Moscow, Russian Federation. 1990.
CP: Russian-Federation.
PY: 1990.
LA: Russian.
LS: English.

Enregistrement 52 de 152 - GeoRef Disc 3: 1985-1992

TI: Genetic types of scandium deposits.
AU: Borisenko-L-F.
AF: Insl. Mineral. Geochem. and Crystallochem. Rare Elements, Moscow, USSR.
SO: Lithology and Mineral Resources. 23; 4, Pages 367-374. 1989.
PB: Consultants Bureau. New York, NY, United States. 1989.
CP: United-States.
PY: 1989.
LA: English.

Enregistrement 59 de 152 - GeoRef Disc 3: 1985-1992

TI: Geology of the Biggejavri Sc-REE occurrence in Finmark, North Norway.
AU: Sandstad-Jan-Sverre.
AF: Geol. Surv. Norw., Trondheim, Norway.
BK: In: Geological Association of Canada, Mineralogical Association of Canada; annual meeting; program with abstracts--Association Geologique du Canada, Association Mineralogique du Canada; reunion annuelle; programme et resumes.
BA: Stearn-Colin-W (chairperson).
SO: Program with Abstracts - Geological Association of Canada; Mineralogical Association of Canada; Canadian Geophysical Union, Joint Annual Meeting. 14; Pages 2. 1989.
PB: Geological Association of Canada. Waterloo, ON, Canada. 1989.
CP: Canada.
PY: 1989.
CN: Geological Association of Canada, Mineralogical Association of CAnada; annual meeting--Association Geologique du Canada, Association Mineralogique du Canada; reunion annuelle. Montreal, PQ, Canada. May 15-17, 1989.
LA: English.

Enregistrement 70 de 152 - GeoRef Disc 3: 1985-1992

TI: O povedenii skandiya v protsesse laterilizalsii gornykh porod.
Translated Title: Behavior of scandium during the rock lateritization process.
AU: Tenyakov-V-A; Edlin-M-G; Miloslavskaya-O-A; Mamedov-V-I.
AF: Vsesoyuznyy Nauchno-issledovatel'skiy Insl. Mineral'nogo Syrya, Moscow, Russian Federation.0
SO: Doklady Akademii Nauk SSSR. 307; 5, Pages 1223-1226. 1989.
PB: Akademiya Nauk SSSR, Moscow, Russian Federation. 1989
CP: Russian-Federation.
PY: 1989.
LA: Russian.

Enregistrement 102 de 152 - GeoRef Disc 3: 1985-1992

TI: Scandian ixiolite, pyrochlore and bazzite in granite pegmatite in Tordal, Telemark, Norway; A contribution to the mineralogy and geochemistry of scandium and tin.
AU: Bergstol-S; Juve-G.
AF: Univ. Trondheim, Geol. Insl., Norges Tek. Hogshole, N-7034 Trondheim NTH, Norway
SO: Mineralogy and Petrology. 38; 4, Pages 229-243. 1988.
PB: Springer-Verlag. Vienna, Austria. 1988.
CP: Austria.
PY: 1988.
LA: English.
LS: German.

Enregistrement 104 de 152 - GeoRef Disc 3: 1985-1992

TI: Determination of scandium in coal fly ash and geological materials by graphite furnace atomic absorption spectrometry and inductively coupled plasma atomic emission spectrometry.
AU: Bettinelli-M; Baroni-U; Pastorelli-N.
AF: ENEL-DCO, Cent. Lab., Piacenza, Italy.
SO: Analyst (London). 112; 1, Pages 23-26. 1987.
PB: The Chemical Society. Cambridge, United Kingdom. 1987.
CP: United-Kingdom.
PY: 1987.

Enregistrement 109 de 152 - GeoRef Disc 3: 1985-1992

TI: Occurrence of scandium and rare earth elements in Jamaican bauxite waste.
AU: Wagh-Arun-S; Pinnock-Willard-R.
AF: Univ. West Indies, Dep. Phys., Kingston, Jamaica.
SO: Economic Geology and the Bulletin of the Society of Economic Geologists. 82; 3, Pages 757-761. 1987.
PB: Economic Geology Publishing Company. Lancaster, PA, United States. 1987.
CP: United-States.
PY: 1987.
LA: English.

Enregistrement 119 de 152 - GeoRef Disc 3: 1985-1992

TI: Redkozemni elementi v ortiti ot gnaysi i migmatichni pegmatiti v Tsentralnite Rodopi.
Translated Title: Rare earth elements in orthiles from gneisses and migmatitic pegmatites in the central Rhodopes.
AU: Aleksiyev-Elen; Cherneva-Zlatka; Daiyeva-Lilan; Stancheva-Elena.
SO: Geokhimiya, Mineralogiya i Petrologiya. 23; Pages 3-17. 1987.
PB: Bulgarska Akademiya na Naukite. Sofia, Bulgaria. 1987.
CP: Bulgaria.
PY: 1987.
LA: Bulgarian.
LS: English.

Enregistrement 124 de 152 - GeoRef Disc 3: 1985-1992

TI: Distribution of Sc, Ta, Hf, Zr, Co, and Fe in the crust of weathering of metalliferous gabbro-norites in Volodarsk-Volyn rock body.
AU: Borisenko-L-F; Chudinov-V-I.
AF: Inst. Mineral., Geochem., and Crystallochem. Rare Elem., Moscow, USSR.
SO: Lithology and Mineral Resources. 21; 1, Pages 33-39. 1986.
PB: Consultants Bureau. New York, NY, United States. 1986.
CP: United-States.
PY: 1986.
OD: 198609.

Enregistrement 125 de 152 - GeoRef Disc 3: 1985-1992

TI: Neobychnaya assotsiatsiya niobiyevogo rutila i skandiyevogo iksiolita iz pegmatitov khrebta Shubar-Baytal (Vostochnyy Kazakhstan).
Translated Title: An unusual association of niobium rutile and scandium ixiolite from pegmatites of the Shubar-Baytal Range, Eastern Kazakhstan.
AU: Nekrasov-Ivan-Yakovlevich; Chistyakova-Nataliya-Il-inichna; Yevstigneyeva-Tat-yana-L-ovna.
AF: Akad. Nauk SSSR, Inst.Eksp. Mineral., Chernogolovka, USSR.
SO: Mineralogicheskiy Zhurnal. 8; 4, Pages 47-57. 1986.
PB: Akademiya Nauk Ukrainy. Kiev, USSR. 1986.
CP: USSR.
PY: 1986.
LA: Russian.
LS: English.

Bibliographie : alliages Al/Sc

1. Z. Ahmad and B.J. Abdul-Aleem: Scandium Alloyed Al 5052: A High Performance Material for Marine Environment, Proc. EuroCorr 2000.
2. Z. Ahmad, A. Ul-Hamid and B.J. Abdul-Aleem: The Corrosion Behavior of Scandium Alloyed Al 5052 in Neutral Sodium Chloride Solution, *Corros. Sci.* 43 (2001) 1227-1243.
3. T. Aiura, N. Sugawara and Y. Miura: The Effect of Scandium on the As-Homogenized Microstructure of 5083 Alloy for Extrusion, *Mater. Sci. Eng.* A 280 (2000) 139-145.
4. T. Aiura and Y. Miura: The Effect of Scandium on the Microstructure of Al Alloys, Proc. Second International Conference on Processing Materials for Properties, eds. B. Mishra and C. Yamauchi, TMS (2000) 41-44.
5. H. Akamatsu, T. Fujinami, Z. Horita and T.G. Langdon: Influence of Rolling on the Superplastic Behavior of an Al-Mg-Sc Alloy after ECAP, *Scripta Mater.* 44 (2001) 759-764.
6. A.A. Alalykin, I.I. Novikov, V.K. Portnoy and V.I. Pavlov: Superplastic Flow of Aluminum Alloys in Recrystallized and Unrecrystallized Condition, Proceedings of the Second International Conference on Aluminium Alloys, October 9-13 1990, Beijing, China 403-407.
7. A.A. Alekseev, E.A. Lukina, M.I. Ermolova and L.B. Khokhlatova: Mechanism of □'-Phase Formation in Al-Li and Al-Li-Mg Systems Alloys, *Mater. Sci. Forum* 396-402 (2002) 989-994.
8. R.A. Altynbaev et al.: Phase Equilibrium in the Al-Ba-Sc System, *Russ. Metall.* (4) (1987) 194-196.
9. V.N. Ananev, L.B. Ber, V.G. Davydov, V.I. Elagin and A.I. Orozov: Structural Aspects of Instabilities in the Properties of Aluminum - Lithium Alloys Subject to Prolonged Low-Temperature Heating, *Russ. J. Non-Ferrous Met.* 38 (7) (1997) 54-61.
10. M.M. Antonova and V.B. Chernogorenko: Resistance to Hydrogen of Al-Sc Alloys, *Russ. J. Applied Chem.* 74 (2001) 396-399.
11. A.J. Ardell: Measurement of Solubility Limits from Data on Precipitate Coarsening, Experimental Methods of Phase Diagram Determination, eds. J.E. Morral, R.S. Schiffman and S.M. Merchant, The Minerals, Metals & Materials Society, 1994, 57-66.
12. M. Asta, S.M. Foiles and A.A. Quong: First-Principles Calculations of Bulk and Interfacial Thermodynamic Properties for fcc-based Al-Sc Alloys, *Phys. Rev. B* 57 (1998) 11265-11275.
13. M. Asta, V. Ozolins, and C. Woodward: A First-Principles Approach to Modeling Alloy Phase Equilibria, *JOM* 53 (9) (2001) 16-19.
14. M. Asta and V. Ozolins: Structural, Vibrational and Thermodynamic Properties of Al-Sc Alloys and Intermetallic Compounds, *Phys. Rev. B* 64 (2001) 094104-1-14.
15. E.S. Balmuth: The Status of Al-Li Alloys, Proceedings of the 4th International Conference on Aluminium Alloys, September 11-16 1994, Vol. III, Atlanta, Georgia, USA 82-89.
16. M.K. Banerjee and S. Bandyopadhyay: Development of Mechanically Alloyed AlSiMg-SiC_p Metal Matrix Composites with Trace Scandium Additions, Proc. ACUN-2: International Composites Conference on Composites in the Transportation Industry Feb. 14-18 2000, Sydney, Australia, Vol 2 733-746.
17. C.W. Bartges, S.E. Baumann, R.W. Hyland, Jr., C.L. Jensen, G.P. Tarcy, K.D. Vinnedge and T.C. Skeen: Memory Disk Sheet Stock and Method, US Patent 5 601 934, Feb. 11 1997.
18. M.F Bartholomeusz, J.A. Wert: Effect of Dislocation Dissociation on Crack Tip Plasticity in $L1_2$ Intermetallic Alloys, *Acta Metall. Mater.* 40 (1992) 673- 682.
19. T.J. Bastow, C.T. Forwood, M.A. Gibson and M.E. Smith: Local Site Symmetry and Electronic Structure of Trialuminide and Related Intermetallic Alloys Probed by Solid-State NMR, *Phys. Rev. B* 58 (6) (1998) 2988-2997.
20. G.I. Batalin, V.S. Sudavtsova and N.N. Mar'yanchik: Thermodynamic Properties of Liquid Binary Alloys of the Al-Sc, Al-V and Al-Ti Systems, *Soviet Progress in Chemistry* (8) (1985) 35-37.

21. S.F. Baumann, E.L. Colvin, R.W. Hyland, Jr. and J.I. Petit: Aluminum Magnesium Alloy Product Containing Dispersoids, US Patent 5 624 632, Apr. 29 1997.

22. Yu.A. Bazin et al.: Possible Reasons for the Modification and Hardening of Aluminium by Scandium (Summary), *Sov. Non-Ferrous Met. Res.* 12 (1984) 414.

23. Yu.A. Bazin, B.A. Baum: About Mechanism of Alloy Modifying with Soluble Additions, *Tsvetnye Metally* 35 (7) (1994) 130-136.

24. N.A. Belov and E.S. Naumova: Prospects for the Design of Structural Cast Eutectic Al-Ce-Ni Alloys, *Russ. Metall.* (6) (1996) 87-90.

25. L.B. Ber and V.G. Davydov: Influence of the Ageing Realization Scheme on the Phase Transformations and Properties of Commercial Aluminium Alloys, *Mater. Sci. Forum* 396-402 (2002) 983-988.

26 P.B. Berbon, S. Komura, A. Utsunomiya, Z. Horita, M. Furukawa, M. Nemoto and T.G. Langdon: An Evaluation of Superplasticity in Aluminum-Scandium Alloys Processed by Equal-Channel Angular Pressing, *Mater. Trans., JIM* 40 (1999) 772-778.

27. A.L. Berezina et al.: Decomposition Morphology and Kinetics in an Al-Sc Alloy, *Phys. Metals* 10 (1990) 296-304.

28. A.L. Berezina et al.: The Influence of Scandium on the Kinetics and Morphology of Decomposition of Alloys of the Al-Li System, *Phys. Met. Metall.* 71 (2) (1991) 167-175.

29. A.L. Berezina, V.A. Mel'nikova, T.A. Monastyrskaya, A.D. Rud' and K.V. Chuistov: The Effect of Sc on the Stabilization of Metastable Phases during Aging of As-Cast Al-(10-14)%Mg Alloys, *Met. Phys. Adv. Tech.* 15 (1) (1995) 97-101.

30. A.L. Berezina, K.V. Chuistov, N.I. Kolobnev, L.B. Khokhlatova and T.A. Monastyrskaya: Sc in Aluminum Alloys, *Mater. Sci. Forum* 396-402 (2002) 741-746.

31. A.L. Berezina, U. Schmidt, T.A. Monastyrskaya, K.V. Chuistov, A.V. Kotko and N.I. Kolobnev: Structural State and Decomposition Kinetics in Rapidly Quenched Al-Sc, Al-Mg-Sc Alloys, *Mater. Sci. Forum* 396-402 (2002) 763-768.

32. A.L. Beresina, N.I. Kolobnev, K.V. Chuistov, A.V. Kotko and O.A. Molebny: Coherent Composite Phases Formation in Aged Al-Li Base Alloys, *Mater. Sci. Forum* 396-402 (2002) 977-981.

33. A.S. Berger, R.W. Siegel: Vacancy-Scandium Interaction in Quenched Copper, *J. Phys. F* 9 (1979) L67-L71.

34. A.S. Berger: Determination of the Electrical Resistivity of Scandium in Aluminum, *J. Less-Common Met.* 71 (1980) 119-126.

35. C. Berthier, M. Minier: Quadrupolar Nuclear Resonance Investigation of Conduction Electrons Charge Density Around a Scandium Impurity in an Aluminium Matrix, *J. Phys. F* 3 (1973) 1268-1273.

36. G. Bester and M. Fähnle: Interpretation of Ab Initio Total Energy Results in a Chemical Language: II. Stability of $TiAl_3$ and $ScAl_3$, *J. Phys., Condens. Matter* 13 (2001) 11551-11565.

37. M.J. Birt et al.: The Fracture Resistance of 1420 and 1421 Al-Mg-Li Alloys, *Scripta Metall. Mater.* 28 (1993) 919-923.

38. N. Blake, M.A. Hopkins: Constitution and Age Hardening of Al-Sc Alloys, *J. Mater. Sci.* 20 (1985) 2861-2867.

39. J.J. Blandin and W. Beck: Status and Activities of European and International SPF-Groups, Proc. Materials Week 2001 October 1-4 2001, Munich, Germany.

40. A.A. Bondarev: Electron Beam Welding of High-Strength Aluminium Alloys, *Paton Weld. J.* (7) (1999) 50-53.

41. E.L. Bradley, III et al.: Superplastic Properties of an Al-2.4Mg-1.8Li-0.5Sc Alloy, *Scripta Metall. Mater.* 25 (1991) 717-721.

42. A.G. Bratukhin et al.: Structure and Mechanical Properties of Welded Joints in Aluminium- Lithium Alloys in Welding with Experimental Fillers with Scandium, *Paton Weld. J.* 5 (1993) 717-721.

43. A.G. Bratukhin et al.: RSR Alloys, Sc-bearing Aluminium Alloys and Aluminium Matrix Composites Applied to Making Aerospace Permanent Joints, *Welding in the World* 33 (1994) 435.

44. A.G. Bratuhin et al.: Aluminium Casting Alloys for Wrought Welded Assemblies for Aviation Purposes, *Welding in the World* 33 (1994) 436-439.

45. A.G. Bratukhin et al.: Advanced Cast Aluminium Alloys for Cast and Deformed Welded Structures for Aviation Technology, *Weld. Inter.* 9 (1995) 897-899.

46. A.G. Bratukhin et al.: Prospects for Using Aluminium-Lithium Alloys for Stamped-Welded Aviation Structures, *Weld. Inter.* 11 (1997) 70-74.

47. R. Braun, B. Lenczowski and G. Tempus: Effect of Thermal Exposure on the Corrosion Properties of an Al-Mg-Sc Alloy Sheet, *Mater. Sci. Forum* 331-337 (2000) 1647-1652.

48. I.G. Brodova, O.A. Chikova, I.V. Polents, P.S. Popel' and V.O. Esin: Effect of Metastable Heterogeneity of Liquid Metallic Solutions on the Structure of Cast Aluminium Alloys, *Casting Processes* 1 (2) (1992) 158-160.

49. I.G. Brodova et al.: Structural Investigations of Rapidly Crystallized Al-Sc Alloys, *Melts* 4 (1992) 392-397.

50. I.G. Brodova, D.V. Bashlikov and I.V. Polents: Influence of Heat Time Melt Treatment on the Structure and the Properties of Rapidly Solidified Aluminum Alloys with Transition Metals, *Mater. Sci. Forum* 269-272 (1998) 589-594.

51. Y.G. Bushuev, V.E. Sylis and E.V. Shulgina: Aluminium and Scandium Alloys: Research and Testing in Space Technology, *Russ. Space Bull.* 3 (3) (1996) 19-21.

52. G. Cacciamani, P. Riani, G. Borzone, N. Parodi, A. Saccone, R. Ferro, A. Pisch and R. Schmid-Fetzer: Thermodynamic Measurements and Assessment of the Al-Sc System, *Intermetallics* 7 (1999) 101-108.

53. J.F. Cannon and H. Tracy Hall: Effect of High Pressure on the Crystal Structures of Lanthanide Trialuminides, *J. Less-Common Met.* 40 (1975) 313-328.

54. M.C. Carroll, M.J. Mills, G.S. Daehn, P.I. Gouma, M.F. Savage and B.R. Dunbar: Effects of Minor Sc and Zr Additions on Commercial Al-Mg-Mn Alloys, Automotive Alloys 1999, ed. S. Das, TMS (2000) 239-246.

55. S. Celotto and T.J. Bastow: ^{45}Sc Nuclear Magnetic Resonance Analysis of Precipitation in Dilute Al-Sc Alloys, *Phil. Mag. A* 80 (2000) 1111-1125.

56. D.J. Chakrabarti et al.: Superplastic Aluminum Products and Alloys, US Patent 5 055 257, Oct. 8 1991.

57. P.P. Chattopadhyay, S. Datta and M.K. Banerjee: On the Formation of V-Phase in Mechanically Alloyed AlSiMg-SiC_p Metal Matrix Composites with Trace Scandium Additions, *Mater. Sci. Eng.* A333 (2002) 67-71.

58. G.M. Cheldieva et al.: Formation and Decomposition of Metastable Phases in Aluminum Alloys, *Russ. Metall.* (6) (1990) 87-90.

59. V.V. Cherkasov et al.: Special Features of the Structure Formation and Properties of Castable Al-Mg Alloys Alloyed with Scandium, *Met. Sci. & Heat Tr.* (6) (1996) 268-270.

60. M.G. Chu and G.J. Hildeman: Aluminum Products Containing Supersaturated Levels of Dispersoids, US Patent 6 004 506, Dec. 21 1999.

61. M.G. Chu and G.J. Hildeman: Supersaturated Aluminium Alloy, European Patent EP 1 111 079 A1, June 27 2001.

62. V.N. Chudin: Fabrication of Sheet Radiators by Shaping - Diffusion Bonding - Brazing, *Weld. Inter.* 11 (1997) 478-480.

63. J.P. Collin: Alliage d'Aluminium à Hautes Teneurs en Scandium et Procédé de Fabrication de cet Alliage, French Patent FR 2 717 827, Sept. 29 1995.

64. F. Costello: Fine Grains from Ukraine's Scandium Stores, *Mater. World* (9) (2000) 23-24.

65. F.A. Costello, J.D. Robson and P.B. Prangnell: The Effect of Small Scandium Additions to AA7050 on the As-Cast and Homogenized Microstructure, *Mater. Sci. Forum* 396-402 (2002) 757-762.

66. D. Cousineau, M. Sahoo, P.D. Newcombe, T. Castles and F.A. Fasoyinu: Grain Refinement of Aluminum Alloy 356.0 with Scandium, Zirconium, and a Combination of Titanium and Boron, Proc. AFS 105th Casting Congress, Apr. 28 - May 1 2001, Dallas, Texas, USA 157-184.

67. C.E. Cross and Ø. Grong: Microstructure and Mechanical Properties of Simulated Al-Mg-Zn Weld Metal Modified with Sc and Zr, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 1441-1446.

68. V.G. Davydov et al.: On Prospects of Application of New 01570 High-Strength Weldable Al-Mg-Sc Alloy in Aircraft Industry, *Mater. Sci. Forum* 217-222 (1996) 1841- 1846.

69. V.G. Davydov et al.: Alloying Aluminum Alloys with Scandium and Zirconium Additives, *Met. Sci. & Heat Tr.* (8) (1996) 347-352.

70. V.G. Davydov, L.B. Ber, V.N. Ananiev, A.I. Orozov and M.V. Samarina: The Heat Treatment Effect on Thermal Stability of Al-Li Alloys at Low Temperatures, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 985-990.

71. V.G. Davydov, T.D. Rostova, V.V. Zakharov, Yu.A. Filalov and V.I. Yelagin: Scientific Principles of Making an Alloying Addition of Scandium to Aluminium Alloys, *Mater. Sci. Eng.* A 280 (2000) 30-36.

72. V.G. Davydov, L.B. Ber, E.Ya. Kapultkin, V.I. Komov, O.G. Ukolova and E.A. Lukina: TTP and TTT Diagrams for Quench Sensitivity and Ageing of 1424 Alloy, *Mater. Sci. Eng.* A 280 (2000) 76-82.

73. V.G. Davydov, J.N. Fridlyander, M.V. Samarina, A.I. Orozov, L.B. Ber, V.I. Yelagin, R. Lang and T. Pfannenmüller: The Heat Treatment of Al-Cu-Li Alloys Ensured the Stability of Structure and Properties at Long Low Temperature Exposure, *Mater. Sci. Forum* 331-337 (2000) 1049-1054.

74. V.G. Davydov, L.B. Ber and V.I. Komov: The TTT and TTP Diagrams of Commercial Aluminum Alloys Used for Quenching Cooling and Ageing Regimes Optimization, Advances in the Metallurgy of Aluminum Alloys, Proc. James T Staley Honorary Symposium on Aluminum Alloys ed. M. Tiryakioglu, ASM (2001) 219-228.

75. A.M. Diskin et al.: Superplasticity of Alloy of the Al-Cu-Mg System with Additions of Transition Metals (Summary), *Sov. Non-Ferrous Met. Res.* 14 (1986) 499- 500.

76. G. Dlubek et al.: Positron Annihilation Studies of Decomposition in Al-Li Based Alloys, Proceedings of the Sixth International Aluminium-Lithium Conference, October 7-11 1991, Garmisch-Partenkirchen, Germany, 63-68.

77. G. Dlubek, S. Krause, H. Krause, A. L. Beresina, V. S. Mikhalenkov and K. V. Chuistov: Positron Studies of Precipitation Phenomena in Al-Li and in Al-Li-X (X=Cu, Mg or Sc) alloys, *J.Phys.: Condens. Matter* 4 (1992) 6317-6328.

78. S.V. Dobatkin, V.V. Zakharov and R.Z. Valiev: Nanostructures in Al-Based Alloys After Severe Plastic Deformation, Proc. First Joint International Conference on Recrystallization and Grain Growth, Eds. G. Gottstein and D.A. Molodov, August 27-31 2001, Aachen, Germany, Publ. by Springer Verlag, 2001 509-514.

79. S.V. Dobatkin: Grain Refinement and Phase Transformations in Al and Fe Based Alloys During Severe Plastic Deformation, Ultrafine Grained Materials II, eds. Y.T. Zhu, T.G. Langdon, R.S. Mishra, S.L. Semiatin, M.J. Saran and T.C. Lowe, TMS, 2002 183-192.

80. V.I. Dobatkin and G.I. Eskin: Relationships Governing Modification and Nondendritic Solidification of Light Alloys, *Casting Processes* 1 (1) (1992) 24-28.

81. T.V. Dobatkina et al.: Section of the Isothermal Tetrahedron of the Al-Mg, Li-Sc System in the Aluminum-Rich Region, *Russ. Metall.* (5) (1992) 125-127.

82. M.S. Domack and D.L. Dicus: Evaluation of Sc-Bearing Aluminum Alloy C557 for Aerospace Applications, *Mater. Sci. Forum* 396-402 (2002) 839-844.

83. L.M. Dougherty, I.M. Robertson, and J.S. Vetrano: A TEM Study of Dynamic Continuous Recrystallization in a Superplastic Al-4Mg-0.3Sc Alloy *Mat. Res. Soc. Symp. Proc.* 601 (2000) 25-30.

84. L.M. Dougherty, I.M. Robertson, J.S. Vetrano and S.M. Bruemmer: A Microstructural Study of the Effect of Particle Aging on Dynamic Continuous Recrystallization in Al-4Mg-0.3Sc, *Mater. Sci. Forum* 357-359 (2001) 93-98.

85. A.M. Drits, B.A. Kopeliovich: Influence of Fine Transition-metal Particles and Grain Structure on Fracture Behavior of Al-Cu-Mg Alloys, *Russ. Metall.* (4) (1985) 147-151.

86. A.M. Drits, T.V. Krymova: 1460 High-Strength Weldable Aluminum-Lithium Alloy, *Russ. J. Non-Ferrous Met.* 37 (3) (1996) 65-72.

87. M.E. Drits et al.: Scandium-Aluminium Interactions in the Aluminium-rich Side of the Al-Sc System, *Russ. Metall.* (4) (1973) 152-154.

88. M.E. Drits et al.: Effect of Alloying on the Strength Characteristics and Weldability of Aluminum Foil, *Met. Sci. & Heat Tr.* (3) (1979) 215-216.

89. M.E. Drits et al.: Effect of REM on the Mechanical Properties of Aluminum Alloys Containing 6.5% Mg, *Met. Sci. & Heat Tr.* (10) (1980) 743-745.

90. M.E: Drits et al.: Mechanism of the Influence of Scandium in Increasing the Strength and Thermal Stability of Alloys in the Al-Mg System, *Sov. Phys. Dokl.* 26 (3) (1981) 344-346.

91. M.E. Drits et al.: Recrystallization of Al-Sc Alloys, *Russ. Metall.* (1) (1982) 148-152.

92. M.E. Drits et al.: Alloy Al-Sc Age-Hardening Kinetics, Diffusion in Metals and Alloys, August 30-September 3 1982, Tihany, Hungary 616-623.

93. M.E. Drits et al.: Homogenization of Alloys in the System Al-Mg-Sc, *Met. Sci. & Heat Tr.* (7) (1983) 550-554.

94. M.E. Drits et al.: Metastable State Diagram of the Al-Sc System in the Range Rich in Aluminium, *Russ. Metall.* (1) (1983) 150-153.

95. M.E. Drits et al.: The Alloying of 01420 Alloy with Scandium, *Sov. Non-Ferrous Met. Res.* 11 (1983) 248-251.

96. M.E. Drits et al.: The Effect of Solution Treatment on the Ageing Processes of Al-Sc Alloys, *Crystal Res. & Technol.* 19 (1984) 1325-1330.

97. M.E. Drits et al.: Ageing of Alloy Al-0.3 at.% Sc, *Phys. Met. Metall.* 57 (6) (1984) 118-126.

98. M.E. Drits et al.: The Effects of Homogenizing Heating on the Properties of Alloys in the Al-Sc and Al-Mg-Sc Systems, *Russ. Metall.* (3) (1984) 192-195.

99. M.E. Drits et al.: Nature of Physicochemical Interactions in the Aluminum-Rich Corner of the Al-Sc-Mn System, *Russ. Metall.* (4) (1984) 229-232.

100. M.E. Drits et al.: Some Properties of the Al_3Sc Phase, *Sov. Non-Ferrous Met. Res.* 12 (1984) 83-85.

101. M.E. Drits et al.: Effect of $ScAl_3$ Phase Dispersity on Hardening of Al-6.3% Mg-0.21% Sc Alloy, *Met. Sci. & Heat Tr.* (4) (1985) 309-312.

102. M.E. Drits et al.: Effect of the Degree of Dispersion of $ScAl_3$ Phase Segregations on the Recrystallisation of Al-Sc Alloys, *Sov. Non-Ferrous Met. Res.* 13 (1985) 309-314.

103. J.B. Dunlop: Phonon Resistivities of Dilute Transition Metal Compounds, *Solid State Comm.* 15 (1974) 13-17.

104. J.B. Dunlop, G. Grüner and A.D. Caplin: Dilute Intermetallic Compounds II Properties of Aluminium Rich Aluminium-Transition Metal Phases, *J. Phys. F* 4 (1974) 2203-2217.

105. J. Dutkiewicz et al.: Effect of Scandium on the Decomposition of Aluminium-Zinc Alloys, *J. Mater. Sci.* 27 (1992) 3032-3035.

106. J. Dutkiewicz et al.: Evolution of Precipitates in AlLiCu and AlLiCuSc Alloys after Age-Hardening Treatment, *Mater. Sci. Eng.* A234-236 (1997) 253-257.

107. V.I. Elagin et al.: Some Features of Decomposition for the Solid Solution of Scandium in Aluminum, *Met. Sci. & Heat Tr.* (7) (1983) 546-549.

108. V.I. Elagin et al.: Influence of Scandium on the Structure and Properties of Al-Zn-Mg Alloys, *Russ. Metall.* (4) (1983) 143-146.

109. V.I. Elagin et al.: Influence of Zirconium Additions on Ageing of Al-Sc Alloys, *Phys. Met. Metall.* 60 (1) (1985) 88-92.

110. V.I. Elagin et al.: Scandium-alloyed Aluminum Alloys, *Met. Sci. & Heat Tr.* (1) (1992) 37-45.

111. V.I. Elagin et al.: Some Features of the Cast Structure of Alloys of the Al-Sc System, *Met. Sci. & Heat Tr.* (6) (1993) 317-319.

112. V.I. Elagin et al.: Effect of Scandium on the Structure and Properties of Alloy Al-5.5Zn- 2.0Mg, *Met. Sci. & Heat Tr.* (7) (1994) 375-380.

113. R.P. Elliott, F.A. Shunk: The Al-Sc (Aluminum-Scandium) System, *Bull. Alloy Phase Diagrams* 2 (2) (1981) 222-223.

114. R.A. Emigh et al.: Superplastic Studies in the Al-Li-Sc-Mg System, Superplasticity in Aerospace II, Eds. T.R. McNelley and H.C. Heikkenen, The Minerals, Metals & Materials Society, 1990 303-315.

115. R.A. Emigh, E.L. Bradley and J.W. Morris, Jr.: The Al-Sc-Li-Mg System as a Potential Source of Superplastically Formable Alloys, Light-Weight Alloys for Aerospace Applications II, Eds. E.W. Lee and N.J. Kim, The Minerals, Metals & Materials Society, 1991 27-43.

116. O. Engler and G. Tempus: On the Influence of Scandium on the Recrystallization Behaviour of Al-Mg Alloys, Proceedings of ICOTOM 11, September 16-20 1996, China.

117. V.N. Eremenko et al.: Phase Equilibria in the Scandium-Silicon System, *Soviet Powder Met. & Met. Cer.* 27 (1989) 967-972.

118. D.G. Eskin: The Effect of Alloying Additives on Structure and Properties of Cast Al-Cu-Si- Mg Alloys, *Z. Metallkd.* 86 (1995) 60.

119. G.I. Éskin: New Light Alloys and Efficient Technologies for Making Them, *Metallurgist* 46 (2) (2002) 39-41.

120. F.A. Fasoyinu, M. Sahoo and R.G. Davies: Grain Refinement of Aluminum Alloy 356.0 with Scandium, Zirconium and a Combination of Tilanium and Boron, Proc. Light Metals 2000, Eds. J. Kazadi and J. Masounave, August 20-23, 2000, Ottawa, Ontario, Canada 241-271.

121. F.A. Fasoyinu, J. Thomson, D. Cousineau, T. Castles and M. Sahoo: Grain Refinement and Thermal Analysis of Al-Mg Alloy 535, Proc. 6th International AFS Conference on Molten Aluminum Processing, Nov. 11-13 2001, Orlando, Florida, USA.

122. V.A. Fedoseev, V.I. Ryazantsev: Mechanical Properties of Welded Joints in New Deformable Aluminium Alloys, *Weld. Inter.* 9 (1995) 231-233.

123. M.T. Fernandes and R.C. Dorward: Aluminum-Magnesium-Scandium Alloys with Zinc and Copper, US Patent 6 139 653, Oct. 31 2000.

124. Yu.A. Filalov: Weldable Aluminium-Magnesium-Scandium System Base Alloys, *Welding in the World* 33 (1994) 428-429.

125. Yu.A. Filalov: Deformable Al-Mg-Sc Alloys and Possible Regions of Their Application, *J. Adv. Mater.* 2 (1995) 386-390.

126. Yu.A. Filalov: Deformable Alloys Based on the Al-Mg-Sc System, *Met. Sci. & Heat Tr.* (6) (1996) 271-274.

127. Yu.A. Filalov: Wrought Alloys of the Al-Mg-Sc System and their Application Prospects in Automobile Manufacturing, *Russ. J. Non-Ferrous Met.* 38 (2) (1997) 47-49.

128. Yu.A. Filatov, V.I. Yelagin and V.V. Zakharov: New Al-Mg-Sc Alloys, *Mater. Sci. Eng.* A 280 (2000) 97-101.

129. B.M. Freidin, Yu.V. Kuz'mich, I.G. Kolesnikova, V.I. Serba and S.G. Khayutin: Manufacture of Aluminum-base Compositions by Mechanical Alloying, *Russ. J. Non-Ferrous Met.* 41 (10) (2000) 57-62.

130. I.N. Fridlyander: Aluminium-Lithium Weldable Alloy 1420 (Alloying System Al-Li-Mg-Zr), Proceedings of the Fifth International Aluminium-Lithium Conference, March 27-31 1989, Williamsburg, Virginia, USA 1359-1364.

131. I.N. Fridlyander, V.S. Sandler and T.I. Nikol'skaya: Dispersoids in Deformed Aluminum Alloys containing Lithium, *Met. Sci. & Heat Tr.* 32 (6) (1990) 466-468.

132. I.N. Fridlyander et al.: Possibility of Creating Weldable Alloys on the Basis of the System Al-Cu-Li, *Met. Sci. & Heat Tr.* (9) (1991) 695-699.

133. I.N. Fridlyander et al.: Soviet Al-Li Alloys for Aerospace Application, Proceedings of the Sixth International Aluminium-Lithium Conference, October 7-11 1991, Garmisch- Partenkirchen, Germany, 35-42.

134. I.N. Fridlyander et al.: The Effect of Scandium on Decomposition Kinetics in Aluminium- Lithium Alloys, Proceedings of the Sixth International Aluminium-Lithium Conference, October 7-11 1991, Garmisch-Partenkirchen, Germany, 107-112.

135. I.N. Fridlyander et al.: Structure and Properties of Al-Li Alloys Alloyed with Scandium, Proceedings of the Sixth International Aluminium-Lithium Conference, October 7-11 1991, Garmisch-Partenkirchen, Germany, 381-386.

136. I.N. Fridlyander et al.: Fatigue Strength of Al-Cu-Li Alloy at Temperature 293-4 K, Proceedings of the Sixth International Aluminium-Lithium Conference, October 7-11 1991, Garmisch-Partenkirchen, Germany, 615-620.

137. I.N. Fridlyander et al.: The Peculiarities of Grain Structure of Aluminium-Lithium Alloys, Proceedings of the Sixth International Aluminium-Lithium Conference, October 7-11 1991, Garmisch-Partenkirchen, Germany, 867-871.

138. I.N. Fridlyander et.al.: High-Strength Weldable 1460 Alloy for Cryogenic Application, Proceedings of the Sixth International Aluminium-Lithium Conference, October 7-11 1991, Garmisch-Partenkirchen, Germany, 1245-1250.

139. I.N. Fridlyander et al.: Investigation of the Phase Equilibria in Aluminum Alloys Containing Lithium, *Met. Sci. & Heat Tr.* (10) (1993) 567-571.

140. I.N. Fridlyander et al.: Grain Structure and Superplasticity of High Strength Al-Zn-Mg-Cu Alloys with Different Minor Additions, *Mater. Sci. Forum* 170-172 (1994) 345-349.

141. J. Fridlyander: Advanced Russian Aluminum Alloys, Proceedings of the 4th International Conference on Aluminium Alloys, September 11-16 1994, Vol. II, Atlanta, Georgia, USA 80-87.

142. J.N. Fridlyander, O.G. Senatorova: Development and Application of High-Strength Al-Zn- Mg-Cu Alloys, *Mater. Sci. Forum* 217-222 (1996) 1813-1818.

143. J.N. Fridlyander et al.: Alloying Components Optimization of Weldable Al-Li-Mg Alloy, *Mater. Sci. Forum* 217-222 (1996) 1847-1851.

144. J.N. Fridlyander et al.: Advanced Weldable Damage Tolerant AlMgLi Alloy for Aircraft Application, *Mater. Sci. Forum* 242 (1997) 249-254.

145. I.N. Fridlyander, L.L. Rokhlin, T.V. Dobatkina, V.V. Kinzhibalo and A.T. Tyvanchuk: Phase Diagram of the Al-Li-Sc System, *Russ. Metall.* (1) (1998) 161-166.

146. J.N. Fridlyander and W. Bozich: The Properties of Semiproducts of 1460 Alloy (Al-Cu-Li-Sc) and 1421 Alloy (Al-Mg-Li-Sc) at 293K and 77K, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 937-941.

147. J.N. Fridlyander, N.I. Kolobnev, L.B. Khokhlatova, E. Loechelt, P.-J. Winkler and T. Pfannenmuller: Properties of New Al-Li-Mg Alloy, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 2055-2058.

148. J.N. Fridlyander, N.I. Kolobnev, L.B. Khokhlatova, L.V. Tarasenko and I.P. Zhegina: Study of the Structure and Properties of 1420 Alloy Modifications for Sheets, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 2059-2063.

149. J.N. Fridlyander, N.I. Kolobnev, L.B. Khokhlatova, A.L. Berezina, A.V. Katko, A. Haszler and C. Keidel: Texture and Grain Structure of Al-Li-Mg-Zr-Sc Alloy Sheets, *Mater. Sci. Forum* 331-337 (2000) 867-870.

150. I.N. Fridlyander: Russian Aluminum Alloys for Aerospace and Transport Applications, *Mater. Sci. Forum* 331-337 (2000) 921-926.

151. J.N. Fridlyander, N.I. Kolobnev, L.B. Khokhlatova, K.-H. Rendigs, G. Tempus, A. Haszler, C. Keidel, T. Pfannenmüller and A.L. Berezina: Structure and Properties of Sheets of 1424 Alloy, *Mater. Sci. Forum* 331-337 (2000) 1393-1398.

152. I.N. Fridlyander: Aluminum Alloys in Aircraft in the Periods of 1970 - 2000 and 2001 - 2015, *Met. Sci. & Heat Tr.* 43 (1) (2001) 6-10.

153. J.N. Fridlyander, L.B. Khokhlatova, N.I. Kolobnev, L.B. Ber, E.I. Shvechkov, K.-H. Rendigs and G. Tempus: Development of Thermally Stabilized 1424 Aluminium-Lithium Alloy for Welded Fuselage Applications, Proc. Materials Week 2001 October 1-4 2001, Munich, Germany.

154. I.N. Fridlyander, L.B. Khokhlatova, N.I. Kolobnev, K. Rendiks and G. Tempus: Thermally Stable Aluminum-Lithium Alloy 1424 for Application in Welded Fuselage, *Met. Sci. & Heat Tr.* 44 (1) (2002) 3-8.

155. J.N. Fridlyander, L.B. Khokhlatova, N.I. Kolobnev, E.I. Shvechkov, I.P. Zhegina, S.A. Karimova, K.-H. Rendigs and G. Tempus: Influence of Environment and Load Frequency on Fatigue Crack Propagation of 1424 Al-Mg-Li Alloy, *Mater. Sci. Forum* 396-402 (2002) 1273-1278.

156. A.S. Fridman et al.: Cross Section of Isothermal Tetrahedron of the Al-Mg-Sc-Zr System at 500°C in the Aluminum-rich Region, *Russ. Metall.* (1) (1992) 207-209.

157. C.L. Fu: Electronic, Elastic and Fracture Properties of Trialuminide Alloys: Al_3Sc and Al_3Ti, *J. Mater. Res.* 5 (5) (1990) 971-979.

158. C.L. Fu and M.H. Yoo: Fundamentals of Mechanical Behavior in Intermetallic Compounds - A Synthesis of Atomistic and Continuum Modelling, Ordered Intermetallics - Physical Metallurgy and Mechanical Behavior, eds. C.T. Liu, R.W. Cahn and G. Sauthoff, 23-28 June 1991, Irsee, Germany 155-164.

159. H. Fujii, M. Sugamata, J. Kaneko and M. Kubota: Effect of Sc Addition on Rapidly Solidified Al-Transition Metal Alloys, *Mater. Sci. Forum* 396-402 (2002) 245-250.

160. S.-I. Fujikawa et al.: Solid Solubility and Residual Resistivity of Scandium in Aluminum, *J. Less-Common Met.* 63 (1979) 87-97.

161. S.-I. Fujikawa: Impurity Diffusion of Scandium in Aluminum, *Defect and Diffusion Forum* 143-147 (1997) 115-120.

162. S.-I. Fujikawa and S. Sakauchi: Kinetics of Precipitation in Al-0.20 mass% Sc Alloys, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 805-810.

163. S.-I. Fujikawa: Scandium in Pure Aluminum and Aluminum Alloys - Its Behavior and Addition Effects, *J. Japan Inst. Light Metals* 49 (1999) 128-144.

164. T. Fujita, Z. Horita and T.G. Langdon: Diffusion in Fine-Grained Al Alloys Having Low and High Angle Grain Boundaries, *Mater. Sci. Forum* 396-402 (2002) 1061-1066.

165. K. Fukunaga et al.: Temperature Dependence of Dislocation Dissociation Mode in $L1_2$ Trialuminides, *Mater. Sci. Eng.* A 234-236 (1997) 594-597.

166. K. Fukunaga et al.: Temperature Dependence of Dislocalion Structure of $L1_2$-Al_3Sc, *Mater. Sci. Eng.* A 239-240 (1997) 202-205.

167. K.-I. Fukunaga and Y. Miura: Electron Microscopic Analysis of Dislocation Structures in $L1_2$-Al_3Sc Intermetallic Compound, *J. Japan Inst. Metals* 62 (1998) 369-376.

168. C.B. Fuller, D.N. Seidman and D.C. Dunand: Creep Properties of Coarse-Grained Al(Sc) Alloys at 300°C, *Scripta Mater.* 40 (1999) 691-696.

169. M. Furukawa, Z. Horita, M. Nemeto and T.G. Langdon: The Relationship Between Microstructural Stability and Superplasticity in Aluminum Alloys Processed by Equal-Channel Angular Pressing, Proc. Light Metals 1999, Eds. M. Bouchard and A. Faucher, August 22-26, 1999, Quebec City, Quebec, Canada 583-592.

170. M. Furukawa, K. Oh-ishi, S. Komura, A. Yamashita, Z. Horita, M. Nemeto and T.G. Langdon: Optimization of Microstructure for Superplasticity Using Equal-Channel Angular Pressing, *Mater. Sci. Forum* 304-306 (1999) 97-102.

171. M. Furukawa, A. Utsunomiya, K. Matsubara, Z. Horita and T.G. Langdon: Influence of Magnesium on Grain Refinement and Ductility in a Dilute Al-Sc Alloy, *Acta Mater.* 49 (2001) 3829-3838.

172. M. Furukawa, A. Utsunomiya, S. Komura, Z. Horita, M. Nemoto and T.G. Langdon: Optimization for Superplasticity in Ultrafine-Grained Al-Mg-Sc Alloys Using Equal-Channel Angular Pressing, *Mater. Sci. Forum* 357-359 (2001) 431-436.

173. M.Furukawa, Z.Horita and T.G.Langdon: The Principles of Processing Using Severe Plastic Deformation: Applications to Aluminum Alloys, Advances in the Metallurgy of Aluminum Alloys, Proc. James T Staley Honorary Symposium on Aluminum Alloys ed. M. Tiryakioglu, ASM (2001) 47-56.

174. M. Furukawa, Z. Horita and T.G. Langdon: Developing Superplasticity at High Strain Rates Through ECAP Processing, Ultrafine Grained Materials II, eds. Y.T. Zhu, T.G. Langdon, R.S. Mishra, S.L. Semiatin, M.J. Saran and T.C. Lowe, TMS, 2002 459-468.

175. I.N. Ganiev et al.: Anodic Behavior of Alloys in the Systems Aluminum-Scandium(Yttrium, Praseodymium, Neodymium) in a Neutral Medium, *J. Applied Chem. USSR* 60 (1986) 1961-1965.

176. I.N. Ganiev: High-Temperature and Electrochemical Corrosion of Aluminum-Scandium Alloys, *Protection of Metals* 31 (1995) 543-546.

177. I.N. Ganiev et al.: Phase Diagram of Al-Zn-Al_2Sc System, *Russ. Metall.* (3) (1995) 125-127.

178. I.N. Ganiev, M.M. Khakdodov and A.É. Berdiev: Ternary Phase Diagrams of Aluminum with Rare Earth Melals, *Met. Sci. & Heat Tr.* 44 (2) (2002) 54.

179. Y. Gao, W. Wu, G. Feng, S. Xu and X. Ruan: Positron Annihilation Lifetime Analysis of 8090 Alloy with Doping Zn, Ag or Sc under Cryogenic Temperatures, *Acta Metall. Sin.* 31 (2) (1995) 91-96.

180. S.V. Gavrilin: Evaluation of the Cracking Resistance of Welded Joints in Welding Alloys of the Al-Zn-Mg System Using Experimental Filler Wires, *Paton Weld. J.* 10 (1998) 202-204.

181. E.P. George, J.A. Horton, W.D. Porter and J.H. Schneibel: Brittle Cleavage of $L1_2$ Trialuminides, *J. Mater. Res.* 5 (8) (1990) 1639-1648.

182. E.P. George et al.: Deformation and Fracture of $L1_2$ Trialuminides, *ISIJ International* 31 (1991) 1063-1075.

183. V.Y. Gertsman, J.S. Vetrano, C.H. Henager,Jr., and S.M. Bruemmer: EBSD Study of Microstructure Evolution in Model Aluminum Alloys During Anealing and High-Temperature Deformation, Proc. First Joint International Conference on Recrystallization and Grain Growth, Eds. G. Gottstein and D.A. Molodov, August 27-31 2001, Aachen, Germany, Publ. by Springer Verlag, 2001 837-842.

184. A. Gholina, S.I. Hulley and P.B. Pragnell: The Development of an Ultra-Fine Isotropic Grain Structure During the Processing of Spray Formed Al-Li-X Alloys, Proceedings of ReX'96, the Third International Conference on Recrystallization and Related Phenomena, October 21 -24 1996, Monterey, California, USA 537-544.

185. A. Gholina and P.B. Pragnell: Cast Microstructure and Dispersoid Formation in Spray Deposited Al-Li Alloys, *Mater. Sci. Techn.* 15 (1999) 328-336.

186. A. Gholina, J. Sarkar, P.J. Withers and P.B. Pragnell: Ultrafine Grain Structures Formed by Thermomechanical Processing of Spray Cast Al-Li Alloys, *Mater. Sci. Techn.* 15 (1999) 605-615.

187. S.V. Golubev et al.: Effect of Viscosity and Electrical Resistance of the Structural State of Al-Sc Melts and the Structure of the Cast Metal, *Russ. Met.* (1) (1991) 44-49.

188. R. Grimes, R.J. Dashwood and H.M. Flower: High Strain Rate Superplastic Aluminium Alloys: The Way Forward?, *Mater. Sci. Forum* 357-359 (2001) 357-362.

189. J. Gröbner, R. Schmid-Fetzer, A. Pisch, G. Cacciamani, P. Riani, N. Parodi, G. Borzone, A. Saccone and R. Ferro: Experimental Investigations and Thermodynamic Calculation in the Al-Mg-Sc System, *Z. Metallkd.* 90 (1999) 872-880.

190. K.A. Gschneider, Jr., F.W. Calderwood: The Al-Sc (Aluminum-Scandium) System, *Bull. Alloy Phase Diagrams* 10 (1) (1989) 34-36.

191. H.-J. Gudladt, P. Nagy: The Cyclic Crack Propagation Behaviour of a Hardenable Polycrystalline Al-Mg-Sc Alloy, *Mater. Sci. Forum* 13/14 (1987) 407-412.

192. Y. Harada and D.C. Dunand: Creep Properties of Al_3Sc and $Al_3(Sc, X)$ Intermetallics, *Acta Mater.* 48 (2000) 3477-3487.

193. E. Hashimoto et al.: Thermomigration of Scandium in Aluminum, *Jap. J Appl. Phys.* 18 (1979) 881-887.

194. J.B. Hedrick: Rare-Earth Metal Prices in the USA ca. 1960 to 1994, *J. Alloys & Compounds* 250 (1997) 471-481.

195. A. Heinz, A. Haszler, C. Keidel, S. Moldenhauer, R. Benedictus and W.S. Miller: Recent Development in Aluminium Alloys for Aerospace Applications, *Mater. Sci. Eng.* A 280 (2000) 102-107.

196. C.H. Henager, Jr., J.S. Vetrano, V.Y. Gertsman and S.M. Bruemmer: Effect of Sn Additions on Superplasticity in Al-Mg-Mn-Sc Alloys, *Mat. Res. Soc. Symp. Proc.* 601 (2000) 323-328.

197. K. Higashi: Recent Advances and Future Directions in Superplasticity, *Mater. Sci. Forum* 357-359 (2001) 345-356.

198. K.-I. Hirano: Studies on Age-Hardenable Aluminium Alloys by Atom-Probe Field-Ion Microscope, *Bull. Mater. Sci.* 12 (1989) 313-323.

199. A. Hoelzl, H. Kaufmann and V. Konkevich: Semi-Solid Casting of Aluminium - Scandium (Zr) Foundry Alloys, Proc. Automotive and Transportation Technology Congress and Exposition (ATTCE 2001), Oct. 2001, Barcelona, Spain, Vol. 4 1-6.

200. Z. Horita, M. Furukawa, K. Oh-ishi, M. Nemoto and T.G. Langdon: Equal-Channel Angular Pressing for Grain Refinement of Metallic Materials, Proc. Fourth International Conference on Recrystallization and Related Phenomena, eds. T. Sakai and H.G. Suzuki, The Japan Institute of Metals, 1999, 301-308.

201. Z. Horita, S. Komura, P.B. Berbon, A. Utsunomiya, M. Furukawa, M. Nemoto and T.G. Langdon: Superplasticity of Ultrafine-Grained Aluminum Alloys Processed by Equal-Channel Angular Pressing, *Mater. Sci. Forum* 304-306 (1999) 91-96.

202. Z. Horita, M. Furukawa, M. Nemoto, A.J. Barnes and T.G. Langdon: Superplastic Forming at High Strain Rates after Severe Plastic Deformation, *Acta Mater.* 48 (2000) 3633-3640.

203. Z. Horita, S. Lee, S. Ota, K. Neishi and T.G. Langdon: Equal-Channel Angular Pressing as a Production Tool for Superplastic Materials *Mater. Sci. Forum* 357-359 (2001) 471-476.

204. Z. Horita, T. Fujinami, K. Sato, S.B. Kang, H.W. Kim and T.G.Langdon: Microstructures and Mechanical Properties of Aluminum Alloys Processed by Equal-Channel Angular Pressing, Advances in the Metallurgy of Aluminum Alloys, Proc. James T Staley Honorary Symposium on Aluminum Alloys ed. M. Tiryakioglu, ASM (2001) 271-275.

205. D.A. Hughes, M.E. Kassner, M.G. Stout and J.S. Vetrano: Metal Forming at the Center of Excellence for the Synthesis and Processing of Advanced Materials, *JOM* 50 (6) (1998) 16-21.

206. K.B. Hyde, A.F. Norman and P.B. Pragnell: The Growth Morphology and Nucleation Mechanism of Primary $L1_2$ Al_3Sc Particles in Al-Sc Alloys, *Mater. Sci. Forum* 331-337 (2000) 1013-1018.

207. K.B. Hyde, A.F. Norman and P.B. Pragnell: The Effect of Cooling Rate on the Morphology of Primary Al_3Sc Intermetallic Particles in Al-Sc Alloys, *Acta Mater.* 49 (2001) 1327-1337.

208. K.B. Hyde, A.F. Norman and P.B. Prangnell: The Effect of Ti on Grain Refinement in Al-Sc Alloys, *Mater. Sci. Forum* 396-402 (2002) 39-44.

209. R.W. Hyland, Jr., R.C. Stiffler: Determination of the Elastic Constants of Polycrystalline Al_3Sc, *Scripta Metall. Mater.* 25 (1991) 473-477.

210. R.W. Hyland, Jr.: Homogeneous Nucleation Kinetics of Al_3Sc in a Dilute Al-Sc Alloy, *Metall. Trans. A* 23A (1992) 1947-1955.

211. R.W. Hyland, Jr., M. Asta, S.M. Foiles and C.L. Rohrer: Al(f.c.c.): $Al_3Sc(L1_2)$ Interphase Boundary Energy Calculations, *Acta Mater.* 46 (1998) 3667-3678.

212. K. Ihara and Y. Miura: High Temperature Deformation of Al-Mg and Al-Mg-Sc Alloys, *Mater. Sci. Forum* 396-402 (2002) 1377-1382.

213. A.Z. Ikromov, I.N. Ganiev and V.V. Kinzhibalo: Equilibrium Phase Diagram of Al-Zn-Sc system at 573 and 773K, *Dokl. Akad. Nauk Tadzh. SSR* (6) (1990) 391-392.

214. R.V. Ilyushenko et al.: Peculiarities of Weakening of Alloy 1420 (Al-Mg-Li System) in Fusion Welding, Proceedings of the Sixth International Aluminium-Lithium Conference, October 7-11 1991, Garmisch-Partenkirchen, Germany, 1251-1256.

215. B. Irving: Scandium Places Aluminum Welding on a New Plateau, *Weld. J.* 76 (7) (1997) 53-57.

216. R.R. Irving: Welded Aircraft: Its Past was Dismal; Its Future is Exciting, Proc. International Symposium on Metal Welding and Applications, Eds. J.P. Boillot and M. Evrard, August 22-26, 1999, Quebec City, Quebec, Canada 3-20.

217. A.Ya. Ishchenko and T.M. Labur: Weldable Scandium-Containing Aluminium Alloys, *Welding and Surfacing Reviews* 9 (1998) 1-109.

218. A.Ya. Ishchenko and T.M. Labur: Welding Technology and Properties of Welded Joints in Aluminium-Lithium Alloys (Review), *Paton Weld. J.* 10 (1998) 360-364.

219. A.Ya. Ishchenko and T.M. Labur: Weldable Aluminium Alloys with Scandium (Review), *Paton Weld. J.* 10 (1998) 389-392.

220. A.Ya. Ishchenko, V.O. Chapor and M.R. Yavorskaya: Effect of Scandium Additions on Weldability of Alloy of Al-Zn-Mg System, *Paton Weld. J.* (11) (2000) 15-17.

221. L.I. Ivanov, V.M. Lazorenko, Yu.M. Platov and V.I. Tovtin: Radiation Stability of Aluminum-Magnesium-Scandium System Alloys, *Phys. Chem. Mater. Treatment* (6) (1989) 496-497.

222. L.L. Ivanov, V.A. Krasnoselov, Yu.M. Platov, V.I. Tovlin, L.S. Toropova and V.K. Shamardin: Effect of Neutron Irradiation on Mechanical Properties of Low-Activated Aluminium-Based Alloys, *Phys. Chem. Mater. Treatment* (4) (1990) 321-323.

223. L.I. Ivanov et al.: Radiation Resistance and Parameters of Activation of Aluminium- Magnesium-Scandium and Aluminium-Magnesium-Vanadium Alloys Under Neutron Irradiation, *J. Nucl. Mater.* 191-194 (1992) 1075-1079.

224. S. Iwamura, M. Nakayama and Y. Miura: Coherency between Al_3Sc Precipitate and the Matrix in Al Alloys Containing Sc, *Mater. Sci. Forum* 396-402 (2002) 1151-1156.

225. X.J. Jiang et al.: Effects of Minor Additions on Precipitation and Properties of Al-Li-Cu-Mg- Zr Alloy, *Scripta Metall. Mater.* 29 (1993) 211-216.

226. X.J. Jiang et al.: Effects of Scandium on the Microstructure and Tensile Behavior of Al-Li- Cu-Mg-Zr Alloy, *Advances in Cryogenic Engineering (Materials)* 40 (1994) 1369-1376.

227. H.-H. Jo, S.-I. Fujikawa: Kinetics of Precipitation in Al-Sc Alloys and Low Temperature Solid Solubility of Scandium in Aluminium studied by Electrical Resistivity Measurements, *Mater. Sci. Eng.* A171 (1993) 151-161.

228. C.-H. Joh, T. Katsube, K. Yamada and Y. Miura: Effect of Sc-Addition on the Precipitation Behavior of an Al-Li-Mg-Cu Alloy, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 799-804.

229. C.-H. Joh, K. Yamada and Y. Miura: Effect of Sc-Addition on the Coarsening Behavior of Al_3Li Precipitates in Al-Li Alloys, *Mater. Trans., JIM* 40 (1999) 439-442.

230. C.-H. Joh, K. Yamada and Y. Miura: The Effect of Sc on the Formation and Growth of PFZ in Al-Li Alloys, *Mater. Sci. Forum* 331-337 (2000) 1037-1042.

231. M.J. Jones and F.J. Humphreys: Interaction of Recrystallization and Precipitation in Binary Aluminium-Scandium Alloys, Proc. First Joint International Conference on Recrystallization and Grain Growth, Eds. G. Gottstein and D.A. Molodov, August 27-31 2001, Aachen, Germany, Publ. by Springer Verlag, 2001 1287-1292.

232. R. Kaibyshev, O. Sitdikov and S. Olenyov: Ultrafine Grain Formation During Equal Channel Angular Extrusion in an Al-Mg-Sc Alloy, Ultrafine Grained Materials II, eds. Y.T. Zhu, T.G. Langdon, R.S. Mishra, S.L. Semiatin, M.J. Saran and T.C. Lowe, TMS, 2002 65-74.

233. R. Kaibyshev, F. Musin, K. Saytaeva and Y. Motohashi: Formation of Ultrafine Grains During Intense Plastic Straining in an Al-Li Alloy at 400°C Ultrafine Grained Materials II, eds. Y.T. Zhu, T.G. Langdon, R.S. Mishra, S.L. Semiatin, M.J. Saran and T.C. Lowe, TMS, 2002 81-87.

234. L. I. Kaygorodova, V.P. Domashnikov: Investigation of the Influence of Scandium on the Structure and Properties of an Aluminium-Magnesium Alloy during Natural Ageing, *Phys. Met. Metall.* 68 (4) (1989) 160-166.

235. L.I. Kaygorodova et al.: The Effect of Small Sc and Mg Addition on Al-Li-Cu-Zr Alloy Structure and Mechanical Properties, Proceedings of the Sixth International Aluminium- Lithium Conference, October 7-11 1991, Garmisch-Partenkirchen, Germany, 363-367.

236. L.I. Kaigorodova et al.: Effects of Small Additions of Scandium and Magnesium on the Structure and Properties of Al-Li-Cu-Zr Alloy upon Natural Aging, *Phys. Met. Metall.* 73 (3) (1992) 281-285.

237. L.I. Kaigorodova et al.: Effects of Small Additions of Magnesium and Scandium on the Structure and Properties of Al-Li-Cu-Zr Alloy upon Artificial Aging, *Phys. Met. Metall.* 73 (3) (1992) 286-290.

238. L.I. Kaigorodova: Natural Aging of Aluminum-Magnesium Alloys: Stabilization of Properties, *Phys. Met. Metall.* 78 (5) (1994) 490-496.

239. L.I. Kaigorodova et al.: Effect of Small Additions of Sc and Zr on the Structure and Mechanical Properties of an Al-Zn-Mg-Cu Alloy, *Phys. Met. Metall.* 81 (1996) 513-519.

240. L.I. Kaigorodova, I.G. Brodova, E.I. Sel'nikhina, and O.R. Shamsheeva: Effect of Small Additions of Sc and Zr on the Fine Structure of an Al-Zn-Mg-Cu Alloy after Rapid Solidification and High-Temperature Annealing, *Phys. Met. Metall.* 90 (3) (2000) 281-287.

241. K.U. Kainer and R. Unal: Powder Metallurgy Processing and Properties of Al-Mg-Sc Alloys, Proc. 1998 Powder Metallurgy World Congress & Exhibition Oct. 18-22 1998, Granada, Spain, 284-288.

242. A.N. Kamardinkin et al.: Isothermal Sections of the Al-Sc-Zr System at 550 and 600°C in the Region Enriched in Aluminum, *Russ. Metall.* (4) (1991) 216-218.

243. G.M. Khan et al.: Influence of Scandium on Structure and Superplasticity of Al-Zn-Mg-Sc-Zr Alloys, *Tsvetnye Metally* 34 (11) (1993) 43-45.

244. M.L. Kharakterova, T.V. Dobatkina: Polythermal Sections of the Al-Cu-Sc System, *Russ. Metall.* (6) (1988) 175-178.

245. M.L. Kharakterova: Phase Composition of Al-Cu-Sc Alloys at Temperatures of 450 and 500°C, *Russ. Metall.* (4) (1991) 195-199.

246. M.L. Kharakterova et al.: Precipitation Hardening in Ternary Alloys of the Al-Sc-Cu and Al- Sc-Si Systems, *Acta Metall. Mater.* 42 (7) (1994) 2285-2290.

247. M.L. Kharakterova et al.: Effect of Scandium and Zirconium on Structure and Age Hardening of the Al-Mg-Si Alloys, *Russ. Metall.* (1) (1997) 104-109.

248. G.V. Kharina and V.P. Kochergin: Corrosion of Alloys of Aluminum with Zinc and Rare Earth Metals in Sodium Metavanadate Solutions, *Protection of Metals* 32 (1996) 134-136.

249. G.V. Kharina and V.P. Kochergin: Corrosion of Aluminum Alloys with Zinc and Rare-Earth Metals in Polyvanadate Solutions, *Russ. J. Applied Chem.* 69 (1996) 1576-1578.

250. G.V. Kharina, M.V. Kuznetsov and V.P. Kochergin: Mechanism and Kinetics of Anodic Dissolution of Aluminum and its Alloys with Zinc and Rare-Earths in a Sodium Polyvanadate Solution, *Russ. J. Electrochem.* 34 (1998) 482-485.

251. I.M. Khatsinskaya et al.: The Structure and Phase Transformations in Al-Li-Mg Alloys Containing Zr and Sc, Proceedings of the 4th International Conference on Aluminium Alloys, September 11-16 1994, Vol. II, Atlanta, Georgia, USA 183-190.

252. L.B. Khokhlatova et al.: Ageing Behaviour and Tensile Properties of 1460 Alloy, *Mater. Sci. Forum* 217-222 (1996) 853-857.

253. L.B. Khokhlatova, L.B. Ber, A.A. Alekseev, N.I. Kolobnev, O.G. Ukolova and E.A. Lukina: Phase Transformation during Long-Term Low Temperature Exposure of 1424 Al-Li-Mg Alloy, *Mater. Sci. Forum* 396-402 (2002) 1395-1398.

254. V.T. Klimov, I.B. Ginko, V.V. Sadkov, V.V. Kashirin and T.V. Krymova: Use of Aluminum-Lithium Alloys in Airplane Structures of the Tupolev Aviation Scientific and Technical Complex, *Russ. J. Non-Ferrous Met.* 38 (3) (1997) 70-74.

255. U. Koch et al.: Advanced Weldable High-Strength Al-Cu-Li Alloy for Aerospace Applications, *Mater. Sci. Forum* 242 (1997) 243-248.

256. O.K. Kolerov et al.: Distinctive Features of Primary Crystallization in Alloy 1570, *Met. Sci. & Heat Tr.* (12) (1994) 649-654.

257. O.K. Kolerov: Kinetics and Texture of Recrystallization in Aluminum Alloy Sheets of Different Thicknesses, *Met. Sci. & Heat Tr.* (3) (1997) 94-96.

258. N.I. Kolobnev et al.: Superplasticity of Al-Mg-Li System Alloys, Proceedings of the Sixth International Aluminium-Lithium Conference, October 7-11 1991, Garmisch- Partenkirchen, Germany, 1053-1056.

259. N.I. Kolobnev et al.: Aluminium-Lithium Alloys Based on the Al-Mg-Li-Zr-Sc System, Proceedings of the 4th International Conference on Aluminium Alloys, September 11-16 1994, Vol. II, Atlanta, Georgia, USA 305-312.

260. N.I. Kolobnev and L.B. Khokhlatova: Multy-Step Ageing Behavior of Al-Li Alloys, Proc. Materials Week 2001 October 1-4 2001, Munich, Germany.

261. S.B. Komarov: Modification of the Structure of Aluminum-Lithium Alloy Ingots, *Russ. J. Non-Ferrous Met.* 37 (9) (1996) 59-63.

262. S.B. Komarov: Heredity in Aluminum/Lithium Alloy Ingot Production, *Russ. J. Non-Ferrous Met.* 40 (9) (1999) 60-62.

263. S. Komura, P.B. Berbon, M. Furukawa, Z. Horita, M. Nemoto and T.G. Langdon: High Strain Rate Superplasticity in an Al-Mg Alloy Containing Scandium, *Scripta Mater.* 38 (1998) 1851-1856.

264. S. Komura, P.B. Berbon, A. Utsunomiya, M. Furukawa, Z. Horita, M. Nemoto and T.G. Langdon: Superplasticity in an Ultrafine-Grained Al-Mg-Sc Alloy Produced by Equal-Channel Angular Pressing, Hot Deformation of Aluminum Alloys II eds. T.R. Bieler, L.A. Lalli and S.R. MacEwen, TMS, USA 1998 125-138.

265. S. Komura, Z. Horita, M. Furukawa, M. Nemoto and T.G. Langdon: Influence of Scandium on Superplastic Ductilities in an Al-Mg-Sc Alloy, *J. Mater. Res.* 15 (2000) 2571-2576.

266. S. Komura, M. Furukawa, Z. Horita, M. Nemoto and T. G. Langdon: Optimizing the Procedure of Equal-Channel Angular Pressing for Maximum Superplasticity, *Mater. Sci. Eng.* A 297 (2001) 111-118.

267. S. Komura, Z. Horita, M. Furukawa, M. Nemoto and T.G. Langdon: An Evaluation of the Flow Behavior during High Strain Rate Superplasticity in an Al-Mg-Sc Alloy, *Metall. Mater. Trans. A* 32A (2001) 707-716.

268. V.I. Kononenko, S.V. Golubev: Phase Diagrams of Binary Systems of Aluminum with La, Ce, Pr, Nd, Sm, Eu, Yb, Sc and Y, *Russ. Metall.* (2) (1990) 193-195.

269. V. Kolroczo, I.J. McColm: Phases in Rapidly Cooled Scandium-Silicon Samples, *J. Alloys & Compounds* 203 (1994) 259-265.

270. B.Ya. Kotur, I.R. Mokra: Ternary Systems Sc-Y-Si and Sc-Lu-Si, *Inorg. Mater.* 30 (1994) 729-732.

271. B.Ya. Kotur: Crystal Chemistry of Ternary Intermetallic Compounds of Scandium with Transition Metals and Carbon, Silicon or Germanium, *J. Alloys & Compounds* 219 (1995) 88-92.

272. L.S. Kramer et al.: Modification of Aluminum Alloys via Scandium Additions, Proceedings of Alumitech '97, May 19-23 1997, Atlanta, Georgia, USA 1231-1236.

273. L.S. Kramer et al.: Scandium in Aluminum Alloys, *Adv. Mater. & Proc.* (10) (1997) 23-24.

274. A.R. Krause, R.A. Chernenkoff and R.G. Davies: The Effect of Transition Metals on the Fatigue Response of a 5754 Type Alloy, Proc. Light Metals 1999, Eds. M. Bouchard and A. Faucher, August 22-26, 1999, Quebec City, Quebec, Canada 429-438.

275. A.R. Krause and R.A. Chernenkoff: The Effect of Large Zirconium Additions to a 5754 Alloy, Proc. Light Metals 2000, Eds. J. Kazadi and J. Masounave, August 20-23, 2000, Ottawa, Ontario, Canada 285-294.

276. S. Krause et.al.: Positron Studies of Annealing and Precipitation in Quenched Al-Sc(0.003-6 at%) Alloys, *Mater. Sci. Forum* 105-110 (1992) 1105-1108.

277. S. Krause et al.: Positron Lifetime Studies of Decomposition in Al-Li and Al-Li-(Cu, Mg or Sc) Alloys, *Mater. Sci. Forum* 105-110 (1992) 1109-1112.

278. S. Krause et al.: Defect Annealing and Decomposition in Quenched Al-Sc Alloys Studied by Positron Lifetime Measurements, *Phys. Stat. Sol.* (a) 141 (2) (1994) 311-316.

279. T.M. Labur and R.V. Ilyushenko: Effect of the Composition of Filler Wire on the Failure Resistance of Welded Joints in 01421 Aluminium-Lithium Alloy, *Paton Weld. J.* 4 (1992) 318-320.

280. T.M. Labur and R.V. Ilyushchenko: Effect of Scandium on the Mechanical Properties of Welded Joints in 1420 Aluminium Alloy, *Paton Weld. J.* 4 (1992) 630-631.

281. T.M. Labur: Examining the Efficiency of Hardening the Weld Metal with Scandium in Welding 1420 Aluminium-Lithium Alloy, *Paton Weld. J.* 8 (1996) 391-393.

282. L.K. Lamikhov and G.V. Samsonov: Modification of Aluminum and of Alloy AL7 by Transition Metals, *Tsvetnye Metally* 5 (8) (1964) 77-80.

283. T.G. Langdon, M. Furukawa, M. Nemoto and Z. Horita: Using Severe Plastic Deformation for Grain Refinement and Superplasticity *Mater. Sci. Forum* 357-359 (2001) 489-498.

284. P.Sh. Lantsman et al.: Effect of Alloying with Rare Earth Metals on the Recrystallization Temperature and Properties of Aluminum and an Alloy of the System Al-Cu-Mn, *Met. Sci. & Heat Tr.* (4) (1990) 285-288.

285. S. Lee, A. Utsunomiya, H. Akamatsu, K. Neishi, M. Furukawa, Z. Horita and T.G. Langdon: Influence of Scandium and Zirconium on Grain Stability and Superplastic Ductilities in Ultrafine-Grained Al-Mg Alloys, *Acta Mater.* 50 (2002) 553-564.

286. B. Lenczowski et al.: Neue Aluminiumlegierungen für die Luftfahrt, *Aluminium* 73 (1997) 200-20.

287. B. Lenczowski, R. Rauh, D. Wieser, G. Tempus, G. Fischer, J. Becker, K, Folkers, R. Braun and G. Lütjering: Weldable AlMgSc Alloys for Transportation Technology, *Aluminium* 76 (2000) 350-356.

288. B. Lenczowski, T. Hack, D. Wieser, G. Tempus, G. Fischer, J. Becker, K. Folkers, R. Braun and G. Lütjering: AlMgSc Alloys for Transportation Technology, *Mater. Sci. Forum* 331-337 (2000) 957-963.

289. B. Lenczowski, V. Yelagin, R. Rauh, V. Zakharov and Y. Filatov: Novel Weldable Anti-Corrosive Aluminium-Magnesium Alloy Containing a High Amount of Magnesium, Especially for Use in Automobiles, World Patent WO 0011231, March 11 2000.

290. B. Lenczowski, R. Rauh, D. Wieser and G. Tempus: Weldable, Corrosion-Resistant AlMg Alloys, Especially for Manufacturing Means of Transportation, US Patent 6 258 318, July 10 2001.

291. B. Lenczowski, V. Yelagin, R. Rauh, V. Zakharov and Y. Filatov: Weldable Anti-Corrosive Aluminum-Magnesium Alloy Containing a High Amount of Magnesium, Especially for Use in Automobiles, US Patent 6 315 948, Nov. 13 2001.

292. B. Lenczowski: Neue Leichtmetalle im Flugzeugbau, Proc. Materials Week 2001 October 1-4 2001, Munich, Germany.

293. B. Lenczowski, V. Yelagin, R. Rauh, V. Zakharov and Y. Filatov: Weldable Anti-Corrosive Aluminium-Magnesium Alloy Containing a High Amount of Magnesium, Especially for Use in Aviation, World Patent WO 0011232, March 2 2002.

294. H.A. Lipsitt and A.M. Sherman: Light-Weight Aluminum Alloy Design Methodology, Advances in the Metallurgy of Aluminum Alloys, Proc. James T Staley Honorary Symposium on Aluminum Alloys ed. M. Tiryakioglu, ASM (2001) 385-389.

295. H.A. Lipsitt and A.M. Sherman: Lightweight Aluminum Alloy Design Methodology, *Adv. Mater. & Proc.* (10) (2001) 37-39.

296. V.V. Lilovskii et al.: The Enthalpies of Formation of Liquid Aluminium-Scandium Alloys, *Russ. J. Phys. Chem.* 60 (9) (1986) 1385-1386.

297. J. Liu, D.J. Chakrabarti: Grain Structure and Microtexture Evolution During Superplastic Forming of a High Strength Al-Zn-Mg-Cu Alloy, *Acta Mater.* 44 (1996) 4647-4661.

298. J. Liu and F.H. (Sam) Froes: Aluminum Alloys for Aerospace Applications: A Review, Proc. Synthesis of Lightweight Metals III, eds. F.H. Froes, C.M. Ward-Close, P.G. McCormick and D. Eliezer, TMS (1999) 103-111.

299. J. Liu and M. Kulak: A New Paradigm in the Design of Aluminum Alloys for Aerospace Applications, *Mater. Sci. Forum* 331-337 (2000) 127-140.

300. V.I. Lukin: Effect of Alloying Elements Sc, Mn and Zr on Weldability of Alloys of the Al-Mg-Sc-Mn-Zr System, *Weld. Inter.* 10 (1996) 987-989.

301. V.I. Lukin et al.: Examination of the Weldability of Superlight Al-Mg-Li alloys, *Weld. Inter.* 11 (1997) 488-492.

302. N.A. Makhmudova et al.: Effect of Alloying with Scandium on the Weldability of Al-6%Mg Alloy, *Paton Weld. J.* 3 (1991) 688-690.

303. T.I. Malinkina, N.A. Markachev, V.A. Kovtun and N.M. Bukhanova: Welded Structures of 01570 Aluminium Alloy, *Weld. Inter.* 12 (1998) 566-569.

304. M.V. Markushev and M.Yu. Murashkin: Strength of Submicrocrystalline Severly Deformed Commercial Aluminum Alloys, Ultrafine Grained Materials II, eds. Y.T. Zhu, T.G. Langdon, R.S. Mishra, S.L. Semiatin, M.J. Saran and T.C. Lowe, TMS, 2002 371-380.

305. E.A. Marquis and D.N. Seidman: Nanoscale Structural Evolution of Al_3Sc Precipitates in Al(Sc) Alloys, *Acta Mater.* 49 (2001) 1909-1919.

306. E.A. Marquis, D.N. Seidman and D.C. Dunand: Creep of Precipitation-Strengthened Al(Sc) Alloys, Creep Deformation: Fundamentals and Applications, eds. R.S. Mishra, J.C. Earthman and S.V. Raj, 2002 TMS Annual Meeting, Seattle, Washington, Feb. 17-21 2002, 299-308.

307. L.F. Martynova et al.: Knight Shift in Certain Scandium Compounds, *Phys. Met. Metall.* 37 (1974) 169-170.

308. L. Meng, X.L. Zheng: Overview of the Effects of Impurities and Rare Earth Elements in Al-Li Alloys, *Mater. Sci. Eng.* A237 (1997) 109-118.

309. W.S. Miller, P.C.M. de Haan, A. Haszler, A. Heinz, C. Keidel and H. Ghaziary: High Performance Material for Aerospace Applications, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 1985-1990.

310. Yu.V. Milman, D.V. Lotsko and O.I. Sirko: 'Sc Effect' of Improving Mechanical Properties in Aluminium Alloys, *Mater. Sci. Forum* 331-337 (2000) 1107-1111.

311. Yu.V. Milman, D.V. Lotsko, O.D. Neikov, A.I. Sirko, N.A. Yefimov, A.N. Bilous, D.B. Miracle and O.N. Senkov: Processing, Structure and Mechanical Behavior of Rapidly Solidified Aluminum Alloys Containing Quasicrystalline Particles, *Mater. Sci. Forum* 396-402 (2002) 723-728.

312. Y.V. Milman, A.I. Sirko, D.V. Lotsko, O.N. Senkov and D.B. Miracle: Microstructure and Mechanical Properties of Cast and Wrought Al-Zn-Mg-Cu Alloys Modified with Zr and Sc, *Mater. Sci. Forum* 396-402 (2002) 1217-1222.

313. Y. Miura et al.: Yield Strength of an Al-Sc Alloy Containing Coherent Al_3Sc Precipitates, Aspects of High Temperature Deformation and Fracture in Crystalline Materials, July 28-31 1993, Nagoya, Japan, 255-262.

314. Y. Miura et al.: Precipitation Hardening in an Al-2.4Li- 0.19Sc Alloy, Proceedings of the 4th International Conference on Aluminium Alloys, September 11-16 1994, Vol. II, Atlanta, Georgia, USA 161-168.

315. Y. Miura et al.: Recrystallization of Al-3Mg and Al-3Mg-0.2Sc Alloys, *Mater. Sci. Forum* 217-222 (1996) 505-510.

316. Y. Miura, C.-H. Joh and T. Katsube: Determination of Vacancy-Sc Interacion Energy by Electrical Resistivity Measurements, *Mater. Sci. Forum* 331-337 (2000) 1031-1035.

317. Y. Miyake and T. Suganuma: Superplastic Aluminum Alloy and Process for Producing Same, US Patent 6 056 835, May 2 2000.

318. V.I. Moskvitin and S.V. Makhov: On the Possibility of Manufacturing Aluminum-Scandium Alloying Compounds in an Aluminum Electrolyzer, *Russ. J. Non-Ferrous Met.* 39 (7) (1998) 39-43.

319. M.G. Mousavi: Grain Refinement and Hot Cracking Resistance of Aluminium Weldments, Dr.Ing. Thesis, NTNU, Trondheim, Norway, 1999.

320. M.G. Mousavi, C.E. Cross and Ø. Grong: Effect of Scandium and Titanium-Boron on Grain Refinement and Hot Cracking of Aluminium Alloy 7108, *Sci. Technol. Weld. Joining* 4 (1999) 381-388.

321. T. Mukai, T.G. Nieh, H. Watanabe and K. Higashi: Microstructure and Superplastic Properties in an ECAE Al-4Mg-0.5Sc Alloy Processed at Elevated Temperatures, *Mater. Sci. Forum* 304-306 (1999) 109-114.

322. A.K. Mukhopadhyay, G.M. Reddy, K.S. Prasad, S.V. Kamat, A. Dutta and C. Mondal: Influence of Scandium Additions on the Microstructure and Properties of AA 7010 Alloy Sheets, Advances in the Metallurgy of Aluminum Alloys, Proc. James T Staley Honorary Symposium on Aluminum Alloys ed. M. Tiryakioglu, ASM (2001) 63-71.

323. A.K. Mukhopadhyay and G.M. Reddy: Influence of Trace Addition of Ag on the Weldability of Al-Zn-Mg-Cu-Zr Base 7010 Alloy, *Mater. Sci. Forum* 396-402 (2002) 1665-1670.

324. J. Murken, O. Girard, R. Höhner, B. Skrotzki and G. Eggeler: On the Influence of Stress and Strain on the Coarsening of Precipitates in Al-Alloys under Creep Conditions, *Mater. Sci. Forum* 331-337 (2000) 1507-1512.

325. J. Murken, R. Höhner, B. Skrotzki and G. Eggeler: On the Effect of Combined Thermal and Mechanical Loading on the Microstructural Evolution of an Al-Mg-Li Alloy, *Mater. Sci. Forum* 396-402 (2002) 1291-1296.

326. L.E. Murr, G. Sharma, F. Contreras, M. Guerra, S.H. Kazi, M. Siddique, R.D. Flores, D.J. Shindo, K.F. Soto, E.A. Trillo, C. Schmidt and J.C. McClure: Joining Dissimilar Aluminum Alloys and Other Metals and Alloys by Friction Stir Welding, Aluminum 2001 - Proc. of the TMS 2001 Aluminium Automotive and Joining Sessions, eds. S.K. Das, J.G. Kaufman and T.J. Lienert, TMS, 2001 197-211.

327. J.L. Murray: The Al-Sc (Aluminum-Scandium) System, *J. Phase Equil.* 19 (1998) 380- 384.

328. M.M. Myshlyaev, V.M. Fedorov, L.V. Fedorova and H.J. McQueen: Development of Rapidly-Solidified Aluminum-Transition Metal Alloys for Long-Term Work at Elevated Temperatures, Proc. Hot Workability of Steels and Light Alloys-Composites, Aug. 24-28 1996 Montreal, Quebec, Canada 77-88.

329. M. Nakayama, Y. Miura: The Effect of Scandium on the Age-Hardening Behavior of an Al- Cu Alloy, Proceedings of the 4th International Conference on Aluminium Alloys, September 11-16 1994, Vol. I, Atlanta, Georgia, USA 538-545.

330. M. Nakayama et al.: Precipitation of Al_3Sc in Al-0.23 mass%Sc Alloy, *J. Japan Inst. Metals* 59 (5) (1995) 487-491.

331. M. Nakayama and Y. Miura: Effect of Sc Addition on the Age-Hardening and Precipitation Behavior of Al-2.5 mass%Cu Alloy, , *J. Japan Inst. Light Metals* 46 (1996) 275-279.

332. M. Nakayama et al.: Precipitation of Al_3Sc in Al-0.23 mass%Sc Alloy, *Mater. Trans., JIM* 38 (1997) 852-857.

333. M. Nakayama, T. Okuyama and Y. Miura: Microstructure and Mechanical Properties of Al-2.5%Cu-0.23%Sc Alloy, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 517-522.

334. M. Nakayama, T. Okuyama and Y. Miura: Interaction between □'-Al_2Cu and Al_3Sc in the Heterogeneous Precipitation in an Al-Cu-Sc Alloy, *Mater. Sci. Forum* 331-337 (2000) 927-932.

335. A.V. Nasonov et al.: Wetting of Carbon by Melts of Aluminium with Rare-Earth Metals, *Inorg. Mater.* 24 (1988) 1711-1714.

336. O.P. Naumkin et al.: Phase Equilibrium Diagram and Properties of Aluminium-Scandium Alloys, *Russ. Metall.* (4) (1965) 128-136.

337. O.D. Neikov, D.V. Lotsko, A.I. Sirko, A.V. Sameljuk, G.E. Thompson, N.P. Zakharova and N.A. Yefimov: Properties of Rapidly Solidified Powder Alloys of the Al-Zn-Mg System, *Mater. Sci. Forum* 396-402 (2002) 1223-1228.

338. M. Nemoto, Z. Horita, M. Furukawa and T.G. Langdon: Microstructural Evolution for Superplasticity Using Equal-Channel Angular Pressing, *Mater. Sci. Forum* 304-306 (1999) 59-66.

339. Z. Nie, T. Jin, J. Fu, G. Xu, J. Yang, J. Zhou and T. Zuo: Research on Rare Earth in Aluminum, *Mater. Sci. Forum* 396-402 (2002) 1731-1736.

340. T.G. Nieh et al.: Subgrain Formation and Evolution During the Deformation of an Al-Mg-Sc Alloy at Elevated Temperatures, *Scripta Mater.* 36 (1997) 1011-1016.

341. T.G. Nieh, L.M. Hsiung, J. Wadsworth and R. Kaibyshev: High Strain Rate Superplasticity in a Continuously Recrystallized Al-6%Mg-0.3%Sc Alloy, *Acta Mater.* 46 (1998) 2789-2800.

342. H. Nishimura et al.: A Highly Reliable Via Filling Technology Using High-Temperature Al- Sc Alloy Sputter Deposition, International Electron Devices Meeting 1993, December 5-8 1993, Washington DC, USA 281-284.

343. A.F. Norman and P.B. Prangnell: The Effect of Scandium on the Solidification Behaviour of Aluminium Alloys, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 219-224.

344. A.F. Norman, P.B. Pragnell and R.S. McEwen: The Solidification Behaviour of Dilute Aluminium-Scandium Alloys, *Acta Mater.* 46 (1998) 5715-5732.

345. I.I. Novikov, O.E. Grushko: Hot Cracking Susceptibility of Al-Cu-Li and Al-Cu-Li-Mn Alloys, *Mater. Sci. Techn.* 11 (1995) 926-932.

346. G.M. Novotny and A.J. Ardell: Precipitation of Al_3Sc in binary Al-Sc alloys, *Mater. Sci. Eng.* A 318 (2001) 144-154.

347. V. Ocenasek and M. Slamova: Resistance to Recrystallization due to Sc and Zr Addition to Al-Mg Alloys, *Mater. Charact.* 47 (2001) 157-162.

348. M. Ocko, E. Babic, R. Krsmik, E. Girt and B. Leontic: Some Properties of AlSc Solid Solutions, *J. Phys. F* 6 (1976) 703-707.

349. M. Ocko et al.: Changes of the Lattice Parameter in Al 3*d* Alloys due to the Virtual Bound State, *Solid State Comm.* 18 (1976) 705-708.

350. Kh. O. Odinaev et al.: Phase Equilibrium Diagram of the Al-Mg-Sc System in 0-33.3at.% Sc at 673 K, *Dokl. Akad. Nauk Tadzh. SSR* 32 (1989) 37-38.

351. Kh. O. Odinaev et al.: Quasi-binary Sections and Liquidus Surface of the Al-Mg-Sc System, *Russ. Metall.* (4) (1991) 200-203.

352. S.-I. Ogawa, H. Nishimura: A Novel Al-Sc (Scandium) Alloy for Future LSI Interconnection, International Electron Devices Meeting 1991, December 8-11 1991, Washington DC, USA 277-280.

353. S. Ogawa, H. Nishimura and T. Yamada: Aluminum Interconnection, US Patent 5 759 868, June 2 1998 .

354. S. Ogawa, H. Nishimura and T. Yamada: Aluminum Scandium Alloy Interconnection, US Patent 5 804 879, Sept. 8 1998.

355. K. Oh-ishi, Z. Horita, D.J. Smith and T.G. Langdon: Grain Boundary Structure in Al-Mg and Al-Mg-Sc Alloys after Equal-Channel Angular Pressing, *J. Mater. Res.* 16 (2001) 583-589.

356. H. Okamoto: Al-Sc (Aluminum-Scandium), *J. Phase Equil.* 12 (1991) 612- 613.

357. H. Okamoto: Al-Sc (Aluminum-Scandium), *J. Phase Equil.* 21 (2000) 310.

358. V.V. Ovchinnikov, A.M. Drits and T.V. Krymova: Experience in Applications of Aluminum-Lithium Alloy 1460, *Russ. J. Non-Ferrous Met.* 38 (12) (1997) 31-37.

359. V.V. Ovchinnikov, A.M. Drits and T.V. Krymova: Technological Special Features of Production of Welded Aircraft Structures made of 1460 Aluminium-Lithium Alloy, *Weld. Inter.* 12 (1998) 489-492.

360. V. Ozoliņs and M. Asta: Large Vibrational Effects upon Calculated Phase Boundaries in Al-Sc, *Phys. Rev. Letters* 86 (2001) 448-451.

361. A.B. Pandey, K.L. Kendig and D.B. Miracle: Development of a New Discontinuously Reinforced Aluminum for Space Applications, Affordable MMCs for High Performance Applications, eds. A. Pandey, K. Kendig, and T. Watson, 2001 TMS Fall Meeting, Indianapolis, Nov. 4-8 2001, 35-46.

362. C. Papastaikoudis, D. Papadimitropoulos: Influence of the Virtual Bound State on the Low- Field Hall Coefficient. II. Dilute Alloys of Sc, Ti, V, Co and Ni in Al, *Phys. Rev. B* 24 (1981) 3108-3114.

363. H.G. Paris, T.H. Sanders, Jr., and Y.W. Riddle: Assessment of Scandium Additions in Aluminum Alloy Design, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 499-504.

364. B.A. Parker, Z.F. Zhou: The Mechanical Properties of Aluminium Magnesium Scandium Alloys, Proceedings of the 3rd International Conference on Aluminium Alloys, June 22-26 1992, Vol.I, NTH, Trondheim, Norway 363-367.

365. B.A. Parker et al.: The Effect of Small Additions of Scandium on the Properties of Aluminium Alloys, *J. Mater. Sci.* 30 (1995) 452-458.

366. B.A. Parker: On the Contribution of Coherency Strains to the Strength of Alloys, *Mater. Sci. Forum* 189/190 (1995) 347-351.

367. B.E. Paton, A.Ya. Ishchenko, K.A. Yushchenko, A.G. Bratukhin, A.G. Vovnyanko, E.T. Vasilevskii and A.G. Molyar: Prospects for Using Welding in Construction of New Generation Aircraft, *Paton Weld. J.* 8 (1996) 343-344.

368. B.E. Paton: Problems and Advances in Welding at the Tranistion of the Centuries, *Paton Weld. J.* (7) (1999) 2-11.

369. V.A. Perfilev et al.: Rapid Titrimetric Determination of Scandium in Aluminium Alloys, *Ind. Lab.* 62 (1996) 151.

370. T. Pfannenmüller, E. Loechelt, P.-J. Winkler, S.M. Mozharovskij, D.S. Galkin, E.G. Tolchennikova, V.M. Chertovikov, V.G. Davydov, E.N. Kablov, L.B. Khokhlatova, N.I. Kolobnev and I.N. Fridlyander: Aluminium Based Alloy and Method for Subjecting it to Heat Treatment, World Patent WO 9915708, Apr. 1 1999.

371. A. Pisch, J. Gröbner and R. Schmid-Fetzer: Application of Computational Thermochemistry to Al and Mg Alloy Processing with Sc Additions, *Mater. Sci. Eng.* A 289 (2000) 123-129.

372. A. Pisch, F. Hodaj, P. Chaudouët and C. Colinet: Standard Enthalpies of Formation of some Mn-Y and Mn-Sc Intermetallic Compounds, *J. Alloys & Compounds* 319 (2001) 210-213.

373. Yu. M. Platov, M.N. Pletnev: Phase Instability of Alloys Caused by Transmutation Effects During Neutron Irraditation, *J. Nucl. Mater.* 211 (1994) 95-100.

374. Yu.A. Pokhil et al.: Mechanical Properties of Scandium-Alloyed Aluminium Alloys and their Welded Joints at Cryogenic Temperatures, *Advances in Cryogenic Engineering (Materials)* 42 (1996) 271-276.

375. I.J. Polmear: Control of Precipitation Processes and Properties in Aged Aluminium Alloys by Trace Element Additions, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 75-86.

376. D.P. Pope: Deformation and Fracture of Intermetallic Compounds Having the $L1_2$ Crystal Structure, Ordered Intermetallics - Physical Metallurgy and Mechanical Behavior, eds. C.T. Liu, R.W. Cahn and G. Sauthoff, 23-28 June 1991, Irsee, Germany 143-153.

377. P.S. Popel et al.: Influence of Scandium on the Properties of Liquid Aluminium, *Russ. Metall.* (3) (1983) 38-43.

378. I.N. Pyagai, A.V. Vakhobov: Enthalpy of Formation of Aluminides in the Al-Sc System, *Russ. Metall.* (5) (1990) 50-52.

379. A.H. Ralner, M.B. Geilikman, S.V. Aleksandrovski, F. Jiang, H. Li and Z. Yin: Thermodynamic Calculation on Metallic Thermoreduction during Preparation of Aluminum-Rare Master Alloys, *Trans. Nonferrous Met. Soc. China* 11 (2001) (1) 18-21.

380. G.M. Raynaud: Procédé Permettant de Diminuer le Taux de Recristallisation de l'aluminium et de ses Alliages, FR Patent 2 637 914, Oct. 17. 1988.

381. V.N. Rechkin et al.: Crystal Structures of some Scandium Aluminides, *Sov. Phys. Crystall.* 9 (1964) 325-327.

382. K.-H. Rendigs: Aluminium Structures Used in Aerospace - Status and Prospects, *Mater. Sci. Forum* 242 (1997) 11-23.

383. E.A. Repnikova et al.: Influence of Electron Irradiation on Decomposition of Alloy Al-Mg-Sc, *Phys. Met. Metall.* 57 (3) (1984) 103-106.

384. Y.W. Riddle, H.G. Paris and T.H. Sanders, Jr.: Control of Recrystallization in Al-Mg-Sc-Zr Alloys, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 1179-1184.

385. Y.W. Riddle and T.H. Sanders, Jr.: Recrystallization Performance of AA7050 Varied with Sc and Zr, *Mater. Sci. Forum* 331-337 (2000) 799-803.

386. Y.W. Riddle and T.H. Sanders, Jr.: Contribution of Al_3Sc to Recrystallization Resistance in Wrought Al-Sc Alloys, *Mater. Sci. Forum* 331-337 (2000) 939-944.

387. Y.W. Riddle, M. McIntosh and T.H. Sanders, Jr.: Improving Recrystallization Resistance in Wrought Aluminum Alloys with Scandium Addition, Lightweight Alloys for Aerospace Application VI, eds. K. Jata, E.W. Lee, W. Frazier and N.J. Kim, TMS, 2001 25-39.

388. Y.W. Riddle, H. Hallem and N. Ryum: Highly Recrystallization Resistant Al-Mn-Mg Alloys Using Sc and Zr, *Mater. Sci. Forum* 396-402 (2002) 563-568.

389. O. Roder et al.: Correlation Between Microstructure and Mechanical Properties of Al-Mg Alloys Without and With Scandium, *Mater. Sci. Forum* 217-222 (1996) 1835- 1840.

390. O. Roder et al.: Fatigue Properties of Al-Mg Alloys With and Without Scandium, *Mater. Sci. Eng.* A234-236 (1997) 181-184.

391. C.L. Rohrer, M.D. Asta, S.M. Foiles and R.W. Hyland, Jr.: A Kinetic Model of Precipitate Evolution, *Mat. Res. Soc. Symp. Proc.* 398 (1996) 477-482.

392. L.L. Rokhlin et al.: Formation of Grain Boundaries of a Single Phase Liquid Solution in the Al-Mg-Sc-Zr System, *Russ. Metall.* (6) (1991) 146-148.

393. L.L. Rokhlin et al.: Structure of the Phase Equilibrium Diagrams of Aluminum Alloys with Scandium, *Powder Met. & Met. Cer.* 36 (1997).

394. T.D. Rostova and V.V. Zakharov: Shear Bands in Aluminum Lithium Alloys, *Met. Sci. & Heat Tr.* (6) (1997) 236-239.

395. T.D. Rostova and V.V. Zakharov: Anisotropy of Mechanical Properties of Al-Li Alloy Sheets, *Russ. J. Non-Ferrous Met.* 38 (8) (1997) 59-64.

396. T.D. Rostova, V.G. Davydov, V.I. Yelagin and V.V. Zakharov: Effect of Scandium on Recrystallization of Aluminum and its Alloys, *Mater. Sci. Forum* 331-337 (2000) 793-798.

397. V.I. Ryazantsev, V.A. Fedoseev: Arc Welding Structures of 1420 Aluminium Alloy, *Weld. Inter.* 9 (1995) 311-315.

398. V.I. Ryazantsev, V.A. Fedoseev: Mechanical Properties of Welded Joints in Aluminium Alloys of the Al-Cu System, *Weld. Inter.* 9 (1995) 566-569.

399. V.I. Ryazantsev, V.A. Fedoseev: Technology of Arc-Welding Aluminium Alloys Containing Lithium, *Weld. Inter.* 10 (1996) 983-986.

400. V.I. Ryazantsev, V.A. Fedoseev: Effect of the Arc Welding Conditions and the Composition of Filler Wire on the Mechanical Properties of Welded Joints in Aluminium Alloys, *Weld. Inter.* 11 (1997) 995-998.

401. J. Røyset, N. Ryum: Precipitation and Recrystallization of an Al-Mg-Sc Alloy, Proceedings of the 4th International Conference on Aluminium Alloys, September 11-16 1994, Vol. I, Atlanta, Georgia, USA 194-201.

402. J. Røyset and N. Ryum: Precipitation Kinetics and Mechanisms in a Binary Al-Sc Alloy, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 793-798.

403. J. Røyset, H. Hovland and N. Ryum: An Investigation of Dilute Al-Sc-Si Alloys, *Mater. Sci. Forum* 396-402 (2002) 619-624.

404. A. Saccone, G. Cacciamani, D. Macciò, G. Borzone and R. Ferro: Contribution to the Study of the Alloys and Intermetallic Compounds of Aluminium with the Rare-Earth Metals, *Intermetallics* 6 (1998) 201-215.

405. G.A. Salishchev et al.: Superplasticity of Aluminium Alloys with Ultrafine Grained Structure, Proceedings of the Second International Conference on Aluminium Alloys, October 9-13 1990, Beijing, China 413-415.

406. N. Sano et al.: Precipitation Process of Al-Sc Alloys, *Journal de Physique* 48 C6 (1987) 337-342.

407. N. Sano, H.-H. Jo, , K.-I. Hirano and T. Sakurai: Precipitation Study of an Al-0.25 mass%Sc Alloy, , *J. Japan Inst. Metals* 39 (1989) 444-450.

408. N. Sano et al.: Precipitation Study of an Al-0.25 wt.% Sc Alloy, Proceedings of the Second International Conference on Aluminium Alloys, October 9-13 1990, Beijing, China 549-554.

409. E.M. Savitsky, V.F. Terehova, I.V. Burov and O.P. Naumkin: Study of Rare Earth Crystals and Alloys, Proc. Fourth Conference on Rare Earth Research, ed. L. Eyring, April 22-25 1964, Phoenix, Arizona, USA 409-420.

410. R.R. Sawtell et al.: Superplastic Aluminum Alloys Containing Scandium, US Patent 4 689 090, Aug. 25 1987.

411. R.R. Sawtell and J.W. Morris, Jr.: Exploratary Alloy Development in the System Al-Sc-X, Dispersion Strengthened Aluminium Alloys, January 25-29 1988, Phoenix, Arizona, USA 409-420.

412. R.R. Sawtell et al.: Superplastic Aluminum Products and Alloys, US Patent 4 874 440, Oct. 17, 1989.

413. R.R. Sawtell and C.L. Jensen: Mechanical Properties and Microstructures of Al-Mg-Sc Alloys, *Metall. Trans. A* 21A (1990) 421-430.

414. U. Schmidt, A.L. Beresina, K.V. Chuistov, T.A. Monastyrskaja and A.D. Rud: Decomposition of Rapidly Quenched Supersaturated Al - Sc - X (X: Li, Ta, Ti) Alloys, Proc. NATO-conference on Advanced Light Alloys and Composites,1997, Advanced Study Institute, Zakopane, Poland.

415. U. Schmidt, A.L. Beresina and A.D. Rud: The Decomposition Process in Rapidly Quenched AlLiSc - Alloys, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 787-792.

416. U. Schmidt and B. Schmidt: Modelling of the Transition Kinetics in Al-Alloys, *Mater. Sci. Forum* 331-337 (2000) 889-900.

417. J.H. Schneibel and E.P. George: Microstructure, Compression and Fracture Behavior of Al_3Sc, *Scripta Metall. Mater.* 24 (1990) 1069-1074.

418. J.H. Schneibel and P.M. Hazzledine: The Crystallography of Cleavage Fracture in Al_3Sc, *Mat. Res. Soc. Symp. Proc.* 213 (1991) 323-328.

419. J.H. Schneibel and P.M. Hazzledine: The Crystallography of Cleavage Fracture in Al_3Sc, *J. Mater. Res.* 7 (1992) 868-875.

420. A. Schulz, K. Schimanski and P. Mayr: Spray Forming of Scandium Containing Al-Cu-Alloys, Proc. Int. Conf. On Spray Deposition and Melt Atomisation (SDMA 2000), Bremen, Germany, June 26 - 28 2000 vol. 1, 243-256.

421. G.O. Schumann and R.C. Calcraft: Weldability of High Strength Aluminium-Scandium Alloys, *Australasian Weld. J.* 46 (2001) 46-47.

422. J.C. Schuster and J. Bauer: The Ternary Systems Sc-Al-N and Y-Al-N, *J. Less-Common Met.* 109 (1985) 345-350.

423. G.D. Scott, B.S. Shabel and A. Morales: Aluminum Alloy Suitable for Pistons, US Patent 5 162 065, Nov. 10 1992.

424. E.I. Selnikhina, L.I. Kaigorodova and A.A. Tkachenko: The Formation of the Grain Boundary Structure, Aging Behavior and Mechanical Properties of Al-Zn-Mg-Cu Alloy, *Mater. Sci. Forum* 294-296 (1999) 707-710.

425. O.G. Senatorova, A.N. Uksusnikov, J.N. Fridlyander, J. Koshorst, R.R. Romanova, N.A. Ryazanova, A. Galliot and V.V. Cherkassov: TEM Study of Precipitation in High-Strength 1987 Alloy Sheets after Superplastic Forming, Proceedings of the 6th International Conference on Aluminum Alloys, July 5-10 1998, Toyohashi, Japan 589-593.

426. O.G. Senatorova, A.N. Uksusnikov, S.F. Lehoshina, I.N. Fridlyander and I.P. Zhegina: Influence of Different Minor Additions on Structure and Properties of High-Strength Al-Zn-Mg-Cu Alloy Sheets, *Mater. Sci. Forum* 331-337 (2000) 1249-1253.

427. O.N. Senkov, D.B. Miracle, Y.V. Milman, J.M. Scott, D.V. Lotsko and A. Sirko: Low Temperature Mechanical Properties of Scandium-Modified Al-Zn-Mg-Cu Alloys, *Mater. Sci. Forum* 396-402 (2002) 1127-1132.

428. K.N. Sergeev, T.V. Krymova, A.M. Dritz and S.G. Bulgakova: High-Strength Weldable Aluminum-Lithium Alloy 1460 in Multipurpose Aerospace Systems, *Russ. J. Non-Ferrous Met.* 39 (12) (1998) 25-28.

429. O.A. Setyukov and J.N. Fridlyander: Stress Relaxation in Al Alloys of Al-Mg-Mn, Al-Mg-Sc and Al-Mg-Li-Systems, *Mater. Sci. Forum* 331-337 (2000) 1381-1385.

430. R.E. Shalin et al.: Design and Fabrication of Large Structures of Aluminium-Lithium Alloys for Aerospace Technology, *Weld. Inter.* 11 (1997) 387-392.

431. A.M. Shammazov, N.K. Tsenev, R.Z. Valiev, M.M. Myshlyaev, M.M. Bikbulatov and S.P. Lebedich: High-Strain-Rate Superplasticity of Commercial Grade 1421 and 1460 Aluminum Alloys, *Phys. Met. Metall.* 89 (3) (2000) 314-318.

432. V.G. Shevchenko et al.: Effect of Sc, La and Sm on the Oxidation of Aluminum, *Inorg. Mater.* 22 (1986) 205-208.

433. G.L. Shneider et al.: Stability of Supersaturated Solid Solution of Al-Mg-Li Alloy with Sc Addition, *Tsvetnye Metally* 34 (3) (1993) 44-46.

434. G.L. Shneider, A.M. Drits: Hardenability of Aluminum-Lithium Alloys, *Met. Sci. & Heat Tr.* (9) (1995) 373-377.

435. G.L. Shneider: Phase Transformations in Heat Treatment of Al-Li Alloys and Optimization of Operational Properties of Semifinished Products from these Alloys, *Met. Sci. & Heat Tr.* 40 (1) (1998) 27-33.

436. G.L. Shneider, L.M. Sheveleva and V.V. Kafelnikov: Delayed Fracture of Aluminum Alloys, *Met. Sci. & Heat Tr.* 41 (3) (1999) 109-116.

437. A.B. Shubin, L.F. Yamshchikov, S.P. Yatsenko, S.S. Zobnin and O.B. Yakovlev: Thermodynamic Properties of Intermetallides in the Sc-Al System, *Russ. Metall.* (6) (1999) 145-147.

438. E.I. Shvechkov, T.D. Rostova and V.V. Zakharov: Study of Anisotropy of Mechanical Properties of Alloy 1424 Sheets, *Russ. J. Non-Ferrous Met.* 41 (4) (2000) 95-102.

439. E.I. Shvechkov, T.D. Rostova, V.V. Zakharov and A.V. Demidenkov: Cyclic Endurance of Sheets from Alloy 1424 with Different Thicknesses, *Met. Sci. & Heat Tr.* 43 (4) (2001) 148-151.

440. V.I. Silaeva, B.A. Prusakov and G.I. Eskin: Effect of Microalloying on the Structure and Properties of Alloys in the Al-Si-Cu System, *Met. Sci. & Heat Tr.* 42 (6) (2000) 241-245.

441. O. Simmich et al.: The Effect of Scandium on the Structure of Precipitates in AlLiCu Alloys, *Mater. Sci. Forum* 217-222 (1996) 845-850.

442. V. Singh and A.A. Gokhale: Control of Grain Structure through Transition Elemental Additions in an Al-Li Base Alloy, *Mater. Sci. Forum* 331-337 (2000) 477-482.

443. V. Singh, K.S. Prasad and A.A. Gokhale: Solidification Structure of Aluminium with Trace Additions of Sc and Zr, *Int. J. Cast Metals Res.* 14 (2002) 287-291.

444. V.S. Sinyavskii, V.D. Val'kov and E.V. Titkova: The Effect of Scandium and Zirconium Additions on Corrosion Properties of Al-Mg Alloys, *Protection of Metals* 34 (1998) 549-555.

445. B. Skrotzki, J. Murken and B. Heinz: Comparison of Laser-Beam Welding and Friction Stir Welding of Age-Hardenable Aluminum Alloys, Advances in the Metallurgy of Aluminum Alloys, Proc. James T Staley Honorary Symposium on Aluminum Alloys ed. M. Tiryakioglu, ASM (2001) 343-350.

446. A.F. Smith: Use of Aluminium-Lithium Alloys in Helicopters, Proceedings of Alumitech '97, May 19-23 1997, Atlanta, Georgia, USA 36-50.

447. E.M. Sokolovskaya et al.: Reaction of Aluminum with Chromium and Scandium, *Met. Sci. & Heat Tr.* (11) (1989) 837-839.

448. E.M. Sokolovskaya et al.: Investigation of Rapidly Quenched Aluminum Alloys Hardened with Transition Metals, *Russ. J. Non-Ferrous Met.* 37 (7) (1996) 76-79.

449. E.M. Sokolovskaya et al.: Time-Temperature Section of the Phase Diagram of the Al-Sc-Zr System at 500°C, *Met. Sci. & Heat Tr.* (5) (1997) 211-213.

450. E.M. Sokolovskaya, E.F. Kazakova, V.A. Alikhanov and E.V. Zhuravleva: Interaction between Al_3Sc and Al_6Mn Intermetallic Compounds at 770 K, *Moscow Univ. Chem. Bull.* 52 (5) (1997) 70-72.

451. E.M. Sokolovskaya, E.F. Kazakova and O.D.-S. Kendivan: Polythermal Cross Sections of the Systems Al-V-Me (Me = Zr, Sc) for the $Al_{21}V_2$-$MeAl_3$ Sections, *Russ. Metall.* (4) (1998) 135-137.

452. Y. Songbo, H. Boyun and Y. Zhimin: Effect of Minor Sc on High Temperature Mechanical Properties of Ti-Al Based Alloys, *Mater. Sci. Eng.* A 280 (2000) 204-207.

453. C.J. Sparks et al.: Bonding Energies and Long-Range Order in the Trialuminides, *Mat. Res. Soc. Symp. Proc.* 213 (1991) 363-368.

454. P.K. Spitsyn, O.N. L'vov: Simultaneous Spectrophotometric Determination of Titanium and Scandium in Aluminum Alloys, *Ind. Lab.* 51 (1985) 295-296.

455. J.T. Staley et al.: Aluminum Alloys for Aerostructures, *Adv. Mater. & Proc.* (10) (1997) 17-20.

456. E.A. Starke, Jr., J.T. Staley: Application of Modern Aluminum Alloys to Aircraft, *Prog. Aerospace Sci.* 32 (1996) 131-172.

457. A. Sverdlin, A.M. Drits, T.V. Krimova, K.N. Sergeev and I.B. Ginko: Aluminum-Lithium Alloys for Aerospace, *Adv. Mater. & Proc.* (6) (1998) 49-51.

458. A. Sverdlin, A. Drits and V. Ovchinnikov: Weldability of Aluminum-Copper-Lithium Alloys, Advances in the Metallurgy of Aluminum Alloys, Proc. James T Staley Honorary Symposium on Aluminum Alloys ed. M. Tiryakioglu, ASM (2001) 255-260.

459. W.T. Tack: Aluminum-Scandium Alloys, US Patent 5 597 529, Jan. 28 1997.

460. W.T. Tack and I.L.H. Hansson: Aluminum Alloys Containing Scandium with Zirconium Additions, US Patent 5 620 652, Apr. 15 1997.

461. S. Takayama: Effects of Sc or Tb Addition on the Microstructures and Resistivities of Al Thin Films, *Mat. Res. Soc. Symp. Proc.* 500 (1998) 107-112.

462. C. Tan et al.: The Ageing Behavior and Tensile Properties of Al-Sc Alloy, Proceedings of the 3rd International Conference on Aluminium Alloys, June 22-26 1992, Vol.I, NTH, Trondheim, Norway 290-294.

463. C.Y. Tan et al.: The Ageing Behaviour and Tensile Properties of Al-Li Alloy Containing Sc, Proceedings of the 4th International Conference on Aluminium Alloys, September 11-16 1994, Vol. II, Atlanta, Georgia, USA 329-333.

464. C.-Y. Tan, Z.-Q. Zheng, C.-Q. Xia and Y. Liang: The Ageing Feature of Al-Li-Cu-Mg-Zr Alloy Containing Sc, *J. Cent. South Univ. Technol.* 7 (2) (2000) 65-67.

465. G.P. Tarcy, P.A. Foster, Jr.: Method for making a Light Metal-Rare Earth Metal Alloy, US Patent 5 037 608, Aug. 6 1991.

466. G.P. Tarcy et al.: Method for Making a Light Metal-Rare Earth Metal Alloy, US Patent 5 238 646, Aug. 24 1993.

467. G.P. Tarcy and M.L. Slaugenhaupt: Method of Making a Light Metal-Rare Earth Alloy, US Patent 6 045 631, Apr. 4 2000.

468. J. Tarnacki and Y.-W. Kim: Investigation of As-cast and Rapidly Solified Al_3Sc, *Scripta Metall. Mater.* 23 (1989) 1063-1068.

469. M.Yu. Teslyuk and V.S. Protasov: The Crystal Structure of Ternary Phases in the Sc-Cu-Al System, *Sov. Phys. Crystall.* 10 (1966) 470-471.

470. Y. Tian, B. Sun and Y. Zhai: Preparation of Al-Sc Alloy in Chloride System with Molten Salt Electrolysis, *Trans. Nonferrous Met. Soc. China* 8 (4) (1998) 626-631.

471. Y. Tian, B. Sun and Y. Zhai: Measurement on Physiochemical Properties of NaCl-KCl-$ScCl_3$ System for Manufacture of Al-Sc Alloy by Molten Salt Electrolysis, *J. Mater. Sci. Technol.* (China) 15 (2) (1999) 155-158.

472. T. Torma, E. Kovács-Cseténvi, I. Vitányi, M. Butova and J. Stepanov: Effect of Scandium in High Purity Aluminium, Proc. 6th International Symposium on High Purity Materials in Science and Technology, May 6-10 1985, Akademie der Wissenschaften der DDR, Dresden, GDR, 388-389.

473. T. Torma et al.: The Effect of Scandium Addition on the Mechanical Properties of Pure Aluminium and of an AlMg6 Alloy, *Mater. Sci. Forum* 13/14 (1987) 497-503.

474. T. Torma et al.: Hardening Mechanisms in Al-Sc Alloys, *J. Mater. Sci.* 24 (1989) 3924-3927.

475. L.S. Torodskaya et al.: Polythermal Sections of the Al-Sc-Zr System, *Russ. Metall.* (5) (1992) 128-131.

476. L.S. Toropova et al.: Determination of Elastic Strain of the Matrix due to Particles of Phase $ScAl_3$ in an Al-Mg-Sc Alloy, *Phys. Met. Metall.* 54 (1) (1982) 189-191.

477. L.S. Toropova et al.: Investigation of Alloys of the Al-Sc-Zr System in the Aluminium-rich Range, *Phys. Met. Metall.* 70 (6) (1990) 106-110.

478. L.S. Toropova et al.: Projection of Solidus Surfaces in the Al-rich Region of the Al-Cu-Sc System, *Russ. Metall.* (3) (1992) 194-199.

479. E.D. Trubnyakova et al.: Phase Equilibria in the Aluminum-Rich Corners of the Ternary Systems Al-Sr-Sc(La, Ce, Pr), *Russ. Metall.* (3) (1987) 219-222.

480. N.K. Tsenev et al.: Mechanical Properties of Submicron Grained Al-Li Alloys, Proceedings of the Sixth International Aluminium-Lithium Conference, October 7-11 1991, Garmisch-Partenkirchen, Germany, 1125-1132.

481. N.K. Tsenev et al.: Advanced Properties of Ultra Fine-Grained Al-Alloys, *Mater. Sci. Forum* 242 (1997) 127-134.

482. N.I. Turkina, V.I. Kuzmina: Phase Reactions in Al-Mg-Sc Alloys (up to 26% Mg and 3% Sc), *Russ. Metall.* (4) (1976) 179-183.

483. A.T. Tyvanchuk et al.: Isothermal Section of the Sc-Al-Si System at 770°K, *Russ. Metall.* (4) (1988) 190-192.

484. R. Ünal and K.U. Kainer: Production of High Strength Al-Mg-Sc Alloys by PM, Proc. 1997 European Conference on Advances in Structural PM Component Production (EURO PM 97), Oct. 15-17 1997, Munich, Germany 482-487.

485. R. Ünal and K.U. Kainer: Production of High Strength Al-Mg-Sc Alloys by PM, *Powd. Met.* 41 (2) (1998) 119-122.

486. R. Ünal and K.U. Kainer: PM Production of High Strength Aluminium-Magnesium-Scandium Alloys, *Met. Powd. Report* 54 (2) (1999) 35 (Abstract only).

487. R.Z. Valiev, A.V. Korznikov and R.R. Mulyukov: Structure and Properties of Ultrafine-Grained Materials Produced by Severe Plastic Deformation, *Mater. Sci. Eng.* A 168 (1993) 141-148.

488. V.V. Valuev: Microstructure of Large Ingots of Aluminum Alloy 01570, *Met. Sci. & Heat Tr.* 40 (6) (1998) 234-237.

489. V.A. Vertogradskii and I.N. Belskaya: Dependence of the Thermal Conductivity of Alloys of the Al-Mg System on the Composition and Temperature, *Met. Sci. & Heat Tr.* 40 (6) (1998) 231-233.

490. S.L. Verzasconi, J.W. Morris, Jr.: Cryogenic Mechanical Properties of Low Density Superplastic Al-Mg-Sc Alloys, *Advances in Cryogenic Engineering (Materials)* 36 (1990) 1127-1133.

491. J.S. Vetrano, S.M. Bruemmer, L.M. Pawlowski and I.M. Robertson: Influence of the Particle Size on Recrystallization and Grain Growth in Al-Mg-X Alloys, *Mater. Sci. Eng.* A 238 (1997) 101-107.

492. J.S. Vetrano, C.H. Henager, Jr., M.T. Smith and S.M. Bruemmer: Microstructural Development for Superplasticity in Al-Mg-Mn Alloys, Hot Deformation of Aluminum Alloys II, eds. T.R. Bieler, L.A. Lalli and S.R. MacEwen, TMS, USA 1998 407-418.

493. J.S. Vetrano, C.H. Henager, Jr., S.M. Bruemmer, Y. Ge and C.H. Hamilton: Use of Sc, Zr and Mn for Grain Size Control in Al-Mg Alloys, Superplasticity and Superplastic Forming 1998, eds. A.K. Gosh and T.R. Bieler, TMS, USA 1998 89-97.

494. N.V. Vyazovikina: The Effect of Scandium on the Corrosion Resistance of Aluminum and its Alloys in 3% NaCl Solution, *Protection of Metals* 35 (1999) 448-453.

495. D.J. Waldron and W.F. Bozich: Heat Treated Al-Cu-Li-Sc Alloys, US Patent 6 074 498, June 13 2000.

496. J.-S. Wang: Dislocation Nucleation and the Intrinsic Fracture Behavior of $L1_2$ Intermetallic Alloys, *Acta Mater.* 46 (1998) 2663-2674.

497. Z.F. Wang, P. Wang, C.L. Briant and K.S. Kumar: The Effect of Microstructure on the Polarization and Stress Corrosion Cracking in Al-5Mg Alloys Proc. Corrosion2000, Orlando, Florida, USA 00373/1-12.

498. Z. Wang, P. Wang, K.S. Kumar and C.L. Briant: Stress Corrosion Cracking of Aluminum-Magnesium Alloys Containing Scandium and Silver Additions, Proc. Chemistry and Electrochemistry of Corrosion and Stress Corrosion Cracking, ed. R.H. Jones, TMS, 2001 573-582.

499. A. Washikita, K. Kitagawa, V.I. Kopylov and A. Vinogradov: Tensile and Fatigue Properties of Al-Mg-Sc-Zr Alloy Fine-Grained by Equal-Channel Angular Pressing, Ultrafine Grained Materials II, eds. Y.T. Zhu, T.G. Langdon, R.S. Mishra, S.L. Semiatin, M.J. Saran and T.C. Lowe, TMS, 2002 341-350.

500. T.J. Watson: High Strength Aluminum Alloy, US Patent 6 248 453, June 19 2001.

501. T.J. Watson: High Strength Aluminium Alloy, European Patent EP 1 111 078 A2, June 27 2001.

502. L.A. Willey: Aluminum Scandium Alloy, US Patent 3 619 181, Nov. 9 1971.

503. R. Winkler and J. Wüst: Strukturbauteil aus einer Aluminium-Druckgusslegierung, European Patent EP 0918095 A1, May 26 1999.

504. T. Wirtz, G. Lütjering, A. Gysler, B. Lenczowski and R. Rauh: Fatigue Properties of the Aluminium Alloys 6013 and Al-Mg-Sc, *Mater. Sci. Forum* 331-337 (2000) 1489-1494.

505. J.J. Witters et al.: Evaluation of Al-Li Alloys 1420 and 1421, Proceedings of the Sixth International Aluminium-Lithium Conference, October 7-11 1991, Garmisch-Partenkirchen, Germany, 351-356.

506. R. Wolter et al.: The Description of the Isothermal Decomposition Processes in Al-Sc Alloys by means of Electric Resistivity Measurements and TEM Investigations, *Crystal Res. & Technol.* 28 (1993) 63-72.

507. K.-D. Woo, H.-J. Mun and S.W. Kim: The Effect of Sc on the Precipitation Behavior in Al-Zn-Mg-Cu Alloys, Proc. Fourth Pacific Rim International Conference on Advanced Materials and Processing (PRICM 4), 2547-2550.

508. C. Woodward, M. Asta, G. Kresse and J. Hafner: Density of Constitutional and Thermal Point Defects in $L1_2$ Al_3Sc, *Phys. Rev. B* 63 (2001) 094103-1-6.

509. Y.L. Wu, F.H. Froes, C.G. Li and J. Liu: Effects of Microalloying with Sc, Ni and Ce on the Behavior of Ingot Aluminum Alloy C912 (Al-Zn-Mg-Cu), Synthesis/Processing of Lightweigth Metallic Materials II, Feb. 9-13 1997 Orlando, FL, USA 73-81.

510. Y.-L. Wu, F.H. Froes, C. Li and A. Alvarez: Microalloying of Sc, Ni and Ce in an Advanced Al-Zn-Mg-Cu Alloy, *Metall. Mater. Trans. A* 30A (1999) 1017-1024.

511. Y. Xiao, C. Gao, H. Ma and S. Tian: Effect of Scandium on Superplasticity of Al-Mg Alloys, *Trans. Nonferrous Met. Soc. China* 11 (2001) (2) 235-238.

512. J.-H. Xu and A.J. Freeman: Phase Stability and Electronic Structure of $ScAl_3$ and $ZrAl_3$ and of Sc-stabilized Cubic $ZrAl_3$ Precipitates, *Phys. Rev. B* 41 (1990) 12553-12561.

513. B.F. Yakushin, S.Yu. Nastich: A Rapid Method of Evaluating the Weldability of Aluminium Alloys, *Weld. Inter.* 9 (1995) 915-916.

514. D. Yamaguchi, Z. Horita, T. Fujinami, M. Nemoto and T.G. Langdon: Factors Affecting Grain Refinement in Equal-Channel Angular Pressing, *Mater. Sci. Forum* 331-337 (2000) 607-612.

515. A. Yamashita, D. Yamaguchi, Z. Horita and T.G. Langdon: Influence of Pressing Temperature on Microstructural Development in Equal-Channel Angular Pressing, *Mater. Sci. Eng.* A 287 (2000) 100-106.

516. M.R. Yavorskaya et al.: Increasing the Density and Strength of Weld Metal in the Zone of Backing Runs of Important Components of AMg6NPP Alloy, *Paton Weld. J.* 5 (1993) 172-175.

517. Z. Yin, Q. Pan, Y. Zhang and F. Jiang: Effect of Minor Sc and Zr on the Microstructure and Mechanical Properties of Al-Mg Based Alloys, *Mater. Sci. Eng.* A 280 (2000) 151-155.

518. Z. Yin, L. Yang, Q. Pan and F. Jiang: Effect of Minor Sc and Zr on Microstructures and Mechanical Properties of Al-Zn-Mg based Alloys, *Trans. Nonferrous Met. Soc. China* 11 (2001) (6) 822-825.

519. M.H. Yoo, C.L. Fu: Cleavage Fracture of Ordered Intermetallic Alloys, *Mater. Sci. Eng.* A153 (1992) 470-478.

520. K. Yu, S. Li, W. Li and Y. Xiao: Effect of Trace Sc and Zr on Ageing Behavior and Tensile Properties of 2618 Alloy, *Trans. Nonferrous Met. Soc. China* 9 (3) (1999) 593-598.

521. K. Yu, S. Li and W. Li: Recrystallization Behavior in an Al-Cu-Mg-Fe-Ni Alloy with Trace Scandium and Zirconium, *Mater. Trans., JIM* 41 (2000) 358-361.

522. K.A. Yushchenko et al.: Effect of Scandium on Weldability and Properties of Welded Joints in Aluminium-Magnesium-Lithium System Alloys, *Welding in the World* 35 (1995) 48-51.

523. V.V. Zakharov, T.D. Rostova: On the Possibility of Scandium Alloying of Copper-Containing Aluminum Alloys, *Met. Sci. & Heat Tr.* (2) (1995) 65-69.

524. V.V. Zakharov and T.D. Rostova: High-Resource High-Strength Aluminum Alloys, *Met. Sci. & Heat Tr.* (5) (1995) 203-207.

525. V.V. Zakharov: Industrial Aluminum Alloys with Scandium Additive, *Met. Sci. & Heat Tr.* (7) (1995) 283-285.

526. V.V. Zakharov and T.D. Rostova: Shear Bands in Aluminum Alloys Containing Scandium and Lithium, *Met. Sci. & Heat Tr.* (4) (1996) 163-167.

527. V.V. Zakharov: Stability of the Solid Solution of Scandium in Aluminum, *Met. Sci. & Heat Tr.* (2) (1997) 61-66.

528. V.V. Zakharov and T.D. Rostova: Mechanical Anisotropy in Scandium-Bearing Aluminum Alloy Sheets, *Alum. Trans.* 2 (2000) 329-335.

529. I.I. Zalutskii and P.I. Kripyakevich: RAl_3 Compounds in Rare Earth-Aluminum Systems and their Crystal Structures, *Sov. Phys. Crystall.* 12 (1967) 341-343.

530. V.M. Zamyatin et al.: Surface Tension and Density Polytherms for Molten Aluminium Alloyed with Titanium, Scandium and Iron, *Sov. Non-Ferrous Met. Res.* 14 (1986) 140-143.

531. H. Zhang, H. Uochi, S. Yamazaki, Y. Takemura, M. Miyazaki, A. Murakami, T. Konuma, A. Sugawara and Y. Uehara: Process for Fabricating Electronic Circuits with Anodically Oxidized Scandium Doped Aluminum Wiring, US Patent 5 830 786, Nov. 3 1998.

532. J. Zhang, Z. Yin, Y. Zhang, Y. Gao and Q. Pan: Microstructure of Differently Treated Al-Mg-Sc-Zr Alloys, *J. Cent. South Univ. Technol.* 4 (1) (1997) 24-27.

533. E. Zschech: Metallkundliche Prozesse bei der Wärmebehandlung Aushärtbarer Aluminiumlegierungen, *Härterei-Technische Mitteilungen* 51 (3) (1996) 137-144.

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