Fluorspar illuminated

October 2012 issue

Dr Brian Hodge gives an overview appraisal on the global fluorspar industry and considers why certain information currently publicised is incorrect or misleading, including whether significant fluorspar imports are a realistic option.

The implicit question referred to in the accompanying subtitle reflects a similarly headed part of a widely publicised British Geological Survey (BGS) Open Report OR/08/27, dated 2008, entitled *The need for indigenous fluorspar production in England*. What is substantively considered in the cited report is acid-grade fluorspar (acidspar), with only passing reference made to metallurgical-grade fluorspar (metspar). This situation relates to the evidenced purpose of the 2008 BGS report having been to promote continued production of acidspar in the UK by INEOS Fluor from its then Glebe Mines subsidiary, the Cavendish Mill of which ceased metspar output in 1977 during Laporte's careful ownership of the fluorspar production operations from 1959 to 1999.

Comparable priority attention is given in this appraisal, but on a global rather than a relatively parochial basis, especially in view of concerns widely expressed about the security of acidspar supplies, and ramifications revolving around the material being an internationally traded commodity. In fact, the latter also applies to metspar, but currently with the only significant export sources being Mexico, China and Mongolia, as compared with Mexico, China, South Africa, Kenya, Namibia, Morocco, Mongolia and Spain for acidspar. Nevertheless, due consideration is given to supplies of natural metspar lump/gravel, especially as acidspar, or, more usually, sub-acidspar flotation concentrates, can be agglomerated to form metspar in lump form, while the lump/gravel can normally be upgraded to acidspar by further beneficiation.

Regarding acidspar supplies, with effective reiteration in an article published in the February 2009 issue of **IM**, entitled *European rock and role*, authored by BGS staff members, Linda Hetherington and Andrew Bloodworth, the 2008 BGS report claims that "the English fluorochemical sector is highly dependent on indigenous fluorspar production." In attempting to establish this claim, the report relies upon "the demise of the French fluorochemical sector" as being attributable to the fact that "France lost its only indigenous producer of acid-grade fluorspar" when Sogerem's "operations closed in June 2006". Furthermore, "the French fluorochemical sector" is represented as if it solely comprised "the Arkema Group (...) fluorochemical operations at its plant in Pierre-Bénite".

In fact, the Pierre-Bénite fluorochemical operations have never suffered demise, as evidenced by regular Arkema press releases, commencing with that issued on 22 March 2007, entitled *Arkema continues to reorganize its activities in Rhône-Alpes (France)*, declaring "Arkema's commitment to turn the Pierre-Bénite facility into the flagship site of its Fluorochemicals business in Europe."

This press release is listed as a reference in the BGS report, which also formally acknowledges that "Mr P. Huxtable provided help and guidance regarding the case study of the French fluorspar sector."

Moreover, contrary to the BGS report's representation, "the French fluorochemical sector" is not confined to the operations of Arkema, but also includes the long-established and expanding major fluorochemical production operations of Solvay at Tavaux, Franche-Comté. Of particular note is that this was coincidentally evidenced by an article referring to expansion in Solvay's production of the specialty fluoropolymer PVDF at its Tavaux site, entitled *Solexis boosts PVDF production by 30%*, which appeared on the same page as the accurate item on Arkema in the June 2007 issue of **IM**. Additionally, "the French fluorochemical sector" includes the operations formerly owned by Rhodia at Salindres, Languedoc-Roussillon, which were acquired by Solvay in September 2011.

Both of these facilities continue in production, in common with the ongoing robust health of Arkema's fluorochemical operations at Pierre-Bénite. In fact, as advised by Arkema, this healthy state includes the 2010 restart of HCFC-22 output for use in non-emissive downstream applications, further to mothballing of the plant in 2007 due to financial losses resultant upon declining sales since 2003 because of the phasing out of HCFCs in refrigerant usage by 2010 under the terms of the Montreal Protocol. Such continuity of operations at the three fluorochemical production sites has been maintained in France, despite the country remaining with no indigenous acidspar production.

Minersa's Vergenoeg Mining Company processing plant, South Africa, showing the installation of an additional new mill in order to expand the grinding section and thereby finalise the increase in acidspar production capacity from 180,000 to 300,000 tpa

Glebe Mines closure

A similar situation also prevails in the UK due to the closure of Glebe Mines at the end of 2010, with such closure consequent upon Mexichem Flúor excluding the Glebe subsidiary in completing its acquisition of INEOS Fluor's fluorochemical business on 1 April 2010, and then

deciding not to extend beyond 2010 Glebe's contract for the supply of acidspar. Notwithstanding this situation, Mexichem has proceeded to operate successfully its former ICI/INEOS fluorochemical production facilities at the Rocksavage site, Runcorn, Cheshire, for some 21 months since then, using acidspar imported from Mexico, with such supplies guaranteed in terms of both quantity and quality on a secure long-term basis in view of the company's multiple and extensive captive sources, as amplified variously below.

Therefore, while it is possible to make out a valid case for the exploitation of domestic fluorspar resources on various grounds, such as providing employment as well as promoting local and national economic growth, no support is provided by the prevailing real world circumstances regarding the critical need for indigenous fluorspar production in England. Indeed, an emphatic affirmative is derived therefrom as to significant fluorspar imports being a realistic option, including for acidspar quality, quantity and supply reliability.

Moreover, ICI had previously demonstrated its confidence in satisfactory acidspar imports being a realistic option when it decided in 1999 not to renew the contract for acidspar supply from Laporte's Glebe Mines, and to purchase cheaper material from China. Regarding this action, of particular note is that ICI's decision was taken despite having been reassured of supply reliability from Glebe by a positive detailed audit of the latter's mining operations carried out personally in 1990 under ICI's instructions in accordance with an agreement it made with Laporte. In fact, it was this particular decision of ICI that resulted in Laporte announcing closure of the Glebe operations after 40 years of well-managed ownership, following which the assets were sold to LRM in November 1999.

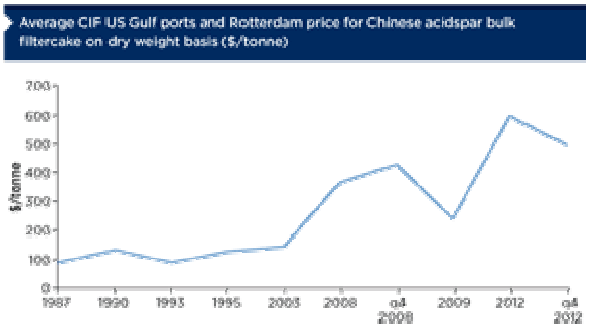
Minersa's Mina Moscona, Spain, showing chambers and pillars in a worked-out area of the stratiform mineralisation

China's receding supply dominance

An outstanding requirement of this consideration is the future contribution of China in view of its dominance since the mid-1980s on world markets for acidspar supplies, as well as those for metspar to a rather lesser extent, but bearing in mind diminishing amounts after 1999, notably in 2009, and its loss of dominance since the latter year.

Indeed, critical questions needing to be addressed revolve around the effect that the availability of Chinese supplies will have on future global requirements being satisfied, especially as speculation has been variously publicised about the country ceasing to export acidspar within five years, and that it may even become a net acidspar importer during that time or by the decade end at the latest.

The dilemma surrounding such speculation concerning acidspar supplies from China is considered in some detail below. This is followed by appropriate but necessarily limited attention to other fluorspar producing countries, with Mexico and South Africa covered initially and in most detail in view of their outstanding importance in the scenario. In quoting amounts, except where it is obvious otherwise, all figures in the following text and accompanying tables are rounded to the nearest 1,000.



China as a producer and consumer

As the world's dominant fluorspar producer since 1984, when it overtook Mexico, China's total output in 2011 is estimated to have reached a record 4.7m tonnes, which includes an increase for acidspar from 2.1 to 2.2m tonnes, with metspar remaining at its 2010 level of 2.5m tonnes. However, total output during the first half of 2012 suffered a drop to 1.86m tonnes, according to data revealed by the Fluorspar Commission of the China Non-Metallic Mineral Industry Association (FCCNMMIA) at a conference in July 2012.

Regarding ongoing supplies to world markets, especially acidspar, despite speculation about the diminution and possible complete cessation of supply, or the country even becoming an importer, complete withdrawal by China from the global supply scene is considered to be unlikely in the foreseeable future. In fact, what is evidently certain is that no impending cessation of supplies exists in view of recent publicity about "substantial inventory reported at Chinese ports."

Nevertheless, imponderability exists in relation to how much further and at what pace the spectacular growth in domestic fluorspar consumption will continue once economic recovery takes place, bearing in mind that reported acidspar demand increased from about 300,000 to nearly 1.8m tonnes between 2001-11, while reported metspar demand from the steel industry rose from some 400,000 to almost 1.6m tonnes during the same period.

As far as the spectacular growth in Chinese fluorspar consumption is concerned, it must not be overlooked that domestic demand may remain static or there is even a reversal, with the latter being at least semi-permanent. In particular, this observation bears in mind that a major excess exists in Chinese and world production capacity for aluminium fluoride (AlF_3) in relation to demand. This has resulted in China already having 50% idle capacity (over 500,000 tonnes) for AlF_3 production, while predictions have been made about further closures of such facilities around the world in addition to those of Alcoa, Industrias Quimicas de México (IQM), and Nitro Quimica.

In extension of the latter, attention is due to an important analytical article, entitled *Aluminium Fluoride (AlF_3) - A market striving towards equilibrium*, published in the March/April 2010 issue of *Aluminium International Today* , authored by Michael Reynolds, which was based on his presentation given at the 2009 **IM** Fluorspar Conference. Other important contributions on relevant matters by the same authority include a presentation, entitled *AlF3: "Too much of a good thing"*, given at the 2008 China Inorganic Fluorine Annual Meeting, and a presentation, entitled *The effects of consolidation in the aluminium and AlF3 industries*, prepared for the 2010 **IM** Fluorspar Conference.

Measures clearly aimed at variously controlling and bringing order to the production capacity for fluorspar, as well as that for HF and AlF_3, including an encouragement of major consolidation and vertical integration, have recently been promulgated by the Chinese Government. These measures include the Ministry of Industry and Information Technology (MIIT), in conjunction with six other ministries, jointly issuing, in March 2010, *Entry Threshold Requirements for Fluorite Industry*; the MIIT issuing, in February 2011, *Entry Criteria for Hydrogen Fluoride Industry*; and the National Development and Reform Commission publishing, in March 2011, *Guided Catalogue for Industrial Structure Adjustment (2011)*, which restricts developments of inorganic fluorine chemicals, notably HF and AlF_3.

Such efficiency measures can only be regarded favourably in relation to conserving resources, so that adequate supplies will remain available to satisfy domestic requirements and allow export markets to be served. Questions about the adequacy of indigenous resources to sustain output, including the evident efforts aimed at their conservation, represent an important factor bearing on the above-mentioned speculation, especially since resources are reportedly declining in quantity and grade, particularly in the coastal provinces.

Consequently, production costs are inevitably rising, with significant contributory factors being the relatively primitive, highly fragmented and labour-intensive methods of mining frequently employed, often with only limited mechanisation. Moreover, the new ore sources required to replace exhausted deposits are more remote from the main export shipping ports of Shanghai, Tianjin and Yantai, so that internal logistic costs have also become inflated. While obviously undesirable for the Chinese industry, such cost increases can only be beneficial to producers elsewhere in the world by exerting upward pressure on Chinese export prices.

Based on available data for Chinese fluorspar output, some 59% (63% for acidspar) previously came from the coastal provinces, in output magnitude order, of Zhejiang, Fujian, Shandong, Hebei and Liaoning, with Zhejiang contributing about 42% of the total for both grades; while

some 16% (20%) came from the provinces of Jiangxi and Anhui, which are contiguous inland with each other as well as the coastal provinces of Fujian and Zhejiang; and the balancing proportion of around 25% (17%) mainly came variously from the provinces further inland of Hunan, Inner Mongolia, Hubei, Henan, Gansu and Shaanxi.

As already indicated, due to the decline in quantity and grade of resources, including orebody exhaustion, in the coastal and immediately adjacent areas, the movement of exploitation to deposits in the inland provinces is proving necessary to increasing extents in order to maintain output. Outstanding in the latter respect, based on available data, are the provinces of Inner Mongolia and Hunan, where large resources reportedly exist, including some in stratiform orebodies hosted variously by favourable limestone and dolomitic limestone.

In addition to production coming from deposits such as those at Chifeng Harquin, Erlianhaote, Obot and Siziwang Qi, in Inner Mongolia, especially notable in view of the mineralisation being stratiform in limestone is that at Sumochagan Obo, which reportedly contains reserves of some 10m tonnes at a grade of 54% CaF_2. Also of potential in the province is the huge Bayan Obo REE-iron-niobium-fluorite deposit, the main host rock of which is dolomite, and which reportedly contains reserves of 132m tonnes at grades in a range of 18-26% CaF_2. However, though acidspar may prove to be recoverable as a by-product from the Bayan Obo ore, no evidence is available to indicate that this can be achieved and is being undertaken yet.

Bearing in mind that the well-known flotation by-product recovery of acidspar from the Taolin lead-zinc vein deposits (containing an average 16% CaF_2) in Hunan has reportedly been closed down for more than a decade, the province's most important deposit is evidently that at Shizhuyuan. This tungsten-tin-fluorite deposit occurs in dolomitic limestone as a stratiform development, which reportedly contains reserves of 46m tonnes at grades in a range of 8-25% CaF_2, though an average grade of 21.7% CaF_2.has been separately reported for the deposit. Output from the polymetallic mineralisation must obviously involve the recovery of acidspar by flotation as a by-product of tungsten and tin concentrate production.

The above examples of major deposits supporting fluorspar production or with potential to do so are not entirely representative of the overall situation because numerous smaller operations are also involved in a highly fragmented manner, with more than 2,000 producing companies referred to recently by the FCCNMMIA. The industry's overall structure is aptly summarised by Minmetals' Dr Lance Wei in an article, entitled *Chinese fluorspar: An overview of production and market trends*, published in the October 1999 issue of **IM**. This states that "fluorspar ore extraction is largely - about 90% - conducted by township, village, and even private enterprises with or without mining licences", with the latter meaning illegal mining, which still occurs, together with smuggling of the commodity.

Substantial evidence exists indicative of China still having major potential for ongoing fluorspar production in that, distributed within 27 of the 32 mainland province-level divisions, over 500 fluorite-bearing ore zones have reportedly been discovered. These include the major deposits identified above, which are reportedly embraced within "more than 30 large and superlarge fluorite deposits and more than 70 medium-sized fluorite deposits", with “large” and “medium-sized” defined as “CaF_2 reserves” respectively at ">1 million tons" and "0.2-1 millions".

Reverting to the speculation about ongoing fluorspar supply security from China to world markets, this has obviously been conditioned by the reported peak acidspar exports of 935,000 tonnes, during 1999, progressively dropping to 196,000 tonnes in 2009. However, there was a 2010 recovery to 386,000 tonnes, and this was consolidated by an increase during 2011 to 433,000 tonnes.

China's metspar exports are now far less significant than those of acidspar in relation to trade, but the pattern is significant in indicating that the available deposits became increasingly less suitable for the manual production of lump/gravel material, though there has evidently been some reversal of this trend recently. Thus, the country's reported peak metspar exports of 804,000 tonnes in 1994 dropped to 200,000 tonnes by 2002 and then progressively fell to 53,000 tonnes in 2007, ahead of a recovery to 212,000 and 289,000 tonnes respectively in 2010 and 2011.

Breakdown data on Chinese acidspar and metspar exports reported for 2011 are presented in the accompanying tables.

Mexico to the fore again

As the world's second largest fluorspar producer, Mexico's reported output increased in 2011 to a record 1.207m tonnes, including acidspar at 732,000 tonnes and metspar at 475,000 tonnes. This rise was from a 2010 level of 1.067m tonnes, which comprised 719,000 tonnes acidspar and 348,000 tonnes metspar. Thus, a major recovery has been achieved from a 1994 low of 235,000 tonnes, when 129,000 tonnes acidspar and 106,000 tonnes metspar made up the total. Such recovery reflects substantial market improvement following severe erosion and a lack of demand attributed to fierce competition from the large and increasing tonnages of very low-priced Chinese acidspar and metspar that were flooded on to global markets from the mid-1980s.

Minera Las Cuevas, now owned by Mexichem Flúor, as the world's largest individual fluorspar producer, contributed some 612,000 tonnes acidspar and 475,000 tonnes metspar in its 2011 total output of 1.087m tonnes. This output is based on the unique and compact Las Cuevas deposit at Salitrera, San Luis Potosi. The remarkable composite deposit, which is open in depth, has declared reserves of 50m tonnes averaging 84% within a range of 73-95% CaF_2 content.

High quality metspar, normally containing 88-90% CaF_2 and 2-3% SiO_2, in various sizings, is produced simply by crushing, washing and screening run-of-mine ore from the Las Cuevas deposit, while the finer fraction provides ideal feed for beneficiation to acidspar. This situation presents flexible options, notably in relation to the amount of metspar produced to satisfy any reasonably foreseeable demand that arises, as is exemplified by annual metspar output being increased by 127,000 tonnes from 348,000 to 475,000 tonnes during the 2010-11 period. Flexibility also exists since metspar can be converted to acidspar by further beneficiation.

Fluorita de Río Verde was acquired by Mexichem in 2008, thereby reinforcing its world premier status as a fluorspar producer. This acquisition includes two flotation plants (one of which was formerly a captive/vertically integrated acidspar supply source for Allied Chemical - now named Honeywell). Advice from the original operators received during site visits was that

installed production capacity in the two flotation plants totalled 165,000 tpa, while there was also a metspar production capacity of 115,000 tpa.

The acquisition also includes mining concessions with highly favourable potential for fluorspar ore production, particularly bearing in mind the existence of the El Refugio and El Realito mines. Moreover, the overall geological setting of the mining concessions is similar to that at Las Cuevas, notably the evident mineralisation-control association of the same Lower Cretaceous limestone host rock and rhyolite intrusions.

Fluorita de México was also acquired by Mexichem after regulatory approval was given in December 2011. In announcing such further enhancement of the company's world premier status as a fluorspar producer, it was declared that "With this acquisition, Mexichem will have access to fluorspar of the highest purity grade worldwide, which will ensure for many years the viability of its operations in England, as well as in Asia." The company also stated that "The mine has proven reserves of over 13 million tons of fluorspar of high purity (...) added to the 50 million tons of reserves of Minera Las Cuevas", and that "the modernization of its activities [will allow Mexichem to increase] its annual production to more than 120,000 tons".

Fluorita de México had an acidspar output of 81,000 tonnes in 2011 from its flotation plant located in the town of Múzquiz, central Coahuila. This operation is based on ore coming from the Sabina mining concessions, situated to the northwest of Múzquiz, in the Buenavista sector of the state's prolific Buenavista-Encantada fluorspar district, where the deposits have an average grade of 60% CaF_2. In amplification of Mexichem's reference to "highest purity grade worldwide", it is well known that Fluorita de México's acidspar product has a low arsenic (As) content of 2 ppm, as well as phosphorus (as P_2O_5) at 180 ppm.

Minera Múzquiz is the only other current Mexican producer of reasonable size. This presently independent company produces acidspar from a flotation plant located near Múzquiz, based on ore mined from deposits at Aguachile in northern Coahuila. The acidspar product is of similar quality to that of Fluorita de México, reportedly "with arsenic (...) virtually nil". This company had an acidspar output of 39,000 tonnes in 2011 (45,000 tonnes in 2010).

Low arsenic in Mexican acidspar

Such ready availability in quantity (currently around 120,000 tpa) of Mexican acidspar with a low As content places into context and refutes the cited 2008 BGS report's erroneous generalisation that "Raw material sourced from Mexico, if available, also contains relatively high arsenic levels." Moreover, a referenced January 2008 Wardell Armstrong report states that "Mexican reserves also suffer from a high arsenic content"; while a related December 2007 Roskill report similarly generalises erroneously by declaring that "Mexican acidspar contains more than 100 ppm arsenic" and that "acidspar from Mexico is high in arsenic, which has restricted its use in HF manufacture in the US and elsewhere".

Las Cuevas standard-grade acidspar does have a relatively high As content, reportedly at up to 360 ppm. Regarding this aspect, the 2008 BGS report states that "Arsenic removal technology would require significant capital investment and time to establish (INEOS Fluor, 2007b)." This

reflects similar observations contained in the Wardell Armstrong and Roskill reports mentioned above. In fact, As-removal technology has been commercially available from specialist fluorine technology company, Buss ChemTech, since the 1980s, and, more importantly, the application of similar technology is already relatively widespread.

As-removal equipment has been installed and operated for lengthy periods of time by several HF production companies, for example, notably by Honeywell, the world's largest HF producer, in its plants at Amherstberg, Canada, and Geismar, US, as well as by Solvay in its plant at Ciudad Juárez, Mexico. Of particular significance for various reasons, which revolve around the company having the practical know-how for appropriate dissemination internally and to acidspar customers, is that Mexichem has As-removal equipment operating in its large vertically integrated HF production facilities at Matamoros, Mexico.

Mexican demand for metspar in the steel industry is relatively modest and is accommodated without making any real impact on the amount available for export. On the other hand, at maximum capacity utilisation, the domestic demand for acidspar in the fluorochemical industry is around 345,000 tpa. Of this maximum demand, 63% relates to the HF production facilities of Mexichem at Matamoros; while the rest is accounted as 21% from Solvay's plant at Ciudad Juárez, and 16% from IQM's plant at San Luis Potosi.

Therefore, contrary to the 2008 BGS report's "if available" remark and the generalisation about "the industry has serious doubts regarding the suitability or reliability of imports to meet English demand", Mexico does, in fact, have large amounts of acidspar and metspar available for export. This includes a substantial quantity of acidspar at no more than 2 ppm As content, as has been shown by Mexichem's imports for its UK fluorochemical production facilities since 2010.

Further to the indication above that appropriate action has already been instituted, additional output from existing producers is also in hand, variously by maximising the use of and even expanding installed capacity, by restoring production from some mothballed facilities, while others could be reactivated. Additionally, the possibility of new production operations being established, subject to consistent demand and attractive prices, cannot be discounted.

As an outline indication of the additional potential available, former acidspar producers include, in descending order of output size, Minera Frisco, Zinc de México, Sesa, La Domincia, Minerales y Productos Metalurgicos, Minera La Valenciana, Fluormex, Alvarez, Fluorita de Hidalgo, Silsea, Bolaños, Minera Comonfort and Minera Tayahua. Some of these also had metspar output, while producers only of such material included Fluorita Nacional, Minerales de Fluorita and members of the Fluorspar Association. These former producers were forced to cease operations during the mid-1980s and culminating in the 1990-1993 period, as a result of becoming non-viable largely due to the previously mentioned competition from cheap Chinese fluorspar.

In summary, based on nominal production capacities related to recent outputs, Mexico has totals in a range of 855-905,000 tpa for acidspar and 475-590,000 tpa for metspar, made up of contributions from Minera Las Cuevas, Fluorita de México, Fluorita de Río Verde and Minera Múzquiz. Subject to it proving possible to restore output at nominal pre-closure maximum

production capacities of the former operations identified above, this would add a total of some 575,000 tpa acidspar and at least 80,000 tpa metspar to Mexican production capacity. However, fulfilment of this situation regarding the restoration of output from former operations cannot be viewed with any real confidence without much more detailed assessment, but the fundamental basis exists in extremely large resources.

A breakdown of the data on Mexico's 2011 acidspar and metspar exports is presented in the accompanying tables.

South Africa ready in the wings

Fluorspar production in South Africa, which is reported as 204,000 tonnes for 2009, is assessed to have fallen in 2010 to 170,000 tonnes, followed by a recovery to 235,000 tonnes in 2011. This assessment is based on one of the two current production operations, the Witkop Fluorspar Mine, having had minimal output from June 2009 until March 2011, due to a lack of demand for acidspar and depressed prices, according to the owner. On the other hand, the other producer, Vergenoeg Mining Company, continued with output during the period Witkop was closed, reporting production of 153,000 tonnes for the year to June 2009, after 181,000 tonnes for the year to June 2008.

Vergenoeg Mining Company (now also referred to internally as VMC Fluorspar), exploits by open-pit mining and adjacent processing operations a very large iron-rich volcanic plug deposit, which is situated near Rust de Winter in northern Gauteng province. Mining of this so-called Kromdraai deposit was originally for iron ore and then metspar, with acidspar production commencing in 1966 after acquisition by Bayer as a captive and vertically integrated supply source for its fluorochemical production facilities in Germany. The mining and processing operations are now 85%-owned by the private Spanish company, Minersa, the sole current and highly experienced fluorspar producer in Spain.

VMC's nominal acidspar production capacity stood for a considerable period at about 180,000 tpa, plus up to around 10,000 tpa of metspar for domestic consumption. However, an announcement was made in 2008 by the then majority owner, Metorex, of plans to increase acidspar production capacity by 40,000 tpa to 220,000 tpa, and then to raise it further to 300,000 tpa. In relation to these plans, Minersa has now exclusively revealed that, as soon as it became the principal owner of VMC in 2009, major capital investment was committed for expansion that will shortly bring acidspar production capacity to the stated 300,000 tpa, with the level having already reached 250,000 tpa.

Regarding quality, published data, including concurrence by statistics in the previously mentioned 2007 Roskill report, show the typical acidspar to contain 3 ppm As and 250 ppm P_2O_5. However, though no standard maximum specification for the Fe_2O_3 content in acidspar exists, the amount in VMC material is recognised as undesirably high, but ongoing efforts have resulted in reducing the level to around 1% Fe_2O_3, even at the expense of fluorspar recovery to some extent. Nevertheless, despite the Fe_2O_3 impurity, it is especially significant regarding acceptability that Bayer (now Lanxess) has used the material for some 45 years and continues to do so. Furthermore, over 95% of VMC acidspar output is taken up in worldwide sales to 11

regular customers on four continents.

Witkop Fluorspar Mine was established as a major acidspar producer by Phelps Dodge, in the Groot Marico district of western North West province to the south of Zeerust, commencing in 1971. The current extensive holdings comprise a contiguous block and three adjacent satellites, totalling some 95km², which embrace extensive dolomite-hosted stratiform fluorite mineralisation, upon which open-pit mining and processing operations are based. These holdings are made up of the amalgamated original properties of Phelps Dodge and the Barlow Rand subsidiary, Marico Fluorspar, which were consolidated as the Witkop Fluorspar Mine before Phelps Dodge sold the entire package to Sallies in 1999.

Majority ownership of the package now rests with Fluormin, which is controlled by the New York-based Firebird investment management group. Production operations were fully reactivated in March 2011, following a 20-month period of minimal output from June 2009, but another output cessation was announced on 12 October 2012, with such action being attributed to "further weakness in the fluorspar market."

This announcement was not entirely unexpected because, though Fluormin had publicised that acidspar production was proceeding at a nominal capacity of 140,000 tpa, its various press releases revealed that the target was not being attained due to identified operating problems. The most fundamentally important of such problems was the reported mill feed grade, in a range of 7.8-8.6% CaF_2, being 27-34% below the budget of 11.8% CaF_2, which itself is a remarkably low grade for supporting viable operations with no significant by-product or co-product credit. Also included among the declared operating problems, each of which will have contributed towards failure to achieve target output, was reported quarterly plant recovery falling as low as 71.1% at times, whereas the assumed level for reserves calculation was 77%.

Subject to the nominal production capacity of 140,000 tpa being achieved, this would represent a 40% increase from the immediately previous level, while the whole output was an expansion on what was available during the 20 months prior to the March 2011 restoration of major output, though obviously only while operations were maintained.

Based on familiarity derived from detailed site involvement with the former Phelps Dodge and Barlow Rand operations, coupled with more recent information, it can be categorically stated that the Witkop acidspar product consistently has very low As, at 2 ppm, and non-detectable P_2O_5 contents, as well as an iron content within normal tolerances at around 0.25% Fe_2O_3.

Accurate quantified data are presented above on the As, Fe_2O_3 , and P_2O_5 contents of the only acidspar available from South Africa since 1994, that is to say, from the VMC and Witkop operations, bearing in mind that the Buffalo Fluorspar Mine was closed in February 1994 and has had no significant acidspar output, if any, since then. Based on details supplied by the Gencor mining house, the long-term owner and operator of Buffalo, its acidspar product contained trace As and 0.24% Fe_2O_3, though the P_2O_5 content was relatively high. However, the P_2O_5 content was reduced from 1,400 to 700 ppm by the introduction of sophisticated processing technology and, at this lower level, the acidspar was of readily saleable quality.

Thus, the presented data refute the cited 2008 BGS report's statement that "South African fluorspar is relatively high in phosphorus, iron and arsenic." The same refutation also applies to the referenced 2008 Wardell Armstrong report generalisation that "Reserves in South Africa have a high arsenic and phosphorous [*sic*] content". Moreover, the 2007 Roskill report is similarly refuted in relation to its declaration that "acidspar (...) from South Africa is high in iron, very fine and also high in phosphorus", which was made despite conflicting with the report's Table 7 showing 250-300 ppm P_2O_5 and no Fe amount for “Minersa, South Africa” (VMC).

Providing consumer demand and attractive prices prevail as incentives, there are also specific possibilities for reasonably early additional contributions to output, as considered briefly below:

Nokeng Fluorspar Project , in northern Gauteng province, of Sephaku Fluoride (SepFluor), which has recently been unbundled from Sephaku Holdings, a Black Economic Empowerment company, and which has been announced as definitely proceeding. The latest publicity, in May 2012, refers to construction of the Nokeng mine and mill now being scheduled to start during the fourth quarter of 2012, with acidspar production targeted to commence in the second quarter of 2014 at an initial rate of 185,000 tpa, followed by reduction in production year six to 130,000 tpa.

The project is based on a well-defined resource, centred about 3km south of the VMC deposit, which has been publicised as SAMREC-compliant and quantified at 11.5m tonnes averaging 29.6% CaF_2 . Full financing of the venture evidently remains outstanding at a declared capital investment of 920m rand ($116m) for the acidspar production facilities alone, with an even larger amount required for the proposed vertically integrated HF and AlF_3 production facilities that would consume 130,000 tpa of the acidspar output. Further news on developments is awaited.

Nevertheless, it is important to note in this context that the Alfluorco HF and AlF_3 project was shelved in 2010 on the grounds of non-viability. This related to a detailed feasibility study revealing that the Internal Return Rate after tax would only be 1.1%. Additionally, an ongoing problem was that insufficient consumption demand exists in South Africa for any such project, especially as plans for the Coega aluminium smelter were scrapped in 2009 due to a lack of power availability. Furthermore, AlF_3 is easily transported and there is a glut of such material available on global markets, as already covered above in the China section.

The repercussions of this situation could, of course, be that the whole of Nokeng acidspar output may become available for export for an indefinite period, thereby adding a significant amount to that available for import.

Buffalo Fluorspar Mine being reactivated by the, as yet, unidentified party, which now controls the production facilities, after their disposal by Fluormin announced on 18 September 2012. Particularly important in relation to restoring output with the minimum of delay is that the 240,000 tpa flotation concentrate production capacity processing plant, established by Gencor, is reportedly mothballed under "care and maintenance", though its actual state is unknown. However, rather than the futile attempt to treat tailings containing 7-8% CaF_2, which was suspended in October 2008, successful output restoration will require the exploitation of virgin

material from new ore reserves by open-pit mining in the exemplary manner previously conducted by Gencor.

Doornhoek Fluorspar Project , of SA Fluorite, has been controlled since November 2009 by the diversified multinational mining group, Eurasian Natural Resources Corporation (ENRC), resultant upon its acquisition of the Central African Mining & Exploration Company (CAMEC). This project, formerly owned by Esso (Exxon) Minerals, then Armco, and subsequently Samancor (a subsidiary of Gencor), relates to holdings of some 100 km² situated immediately east of and interdigitating with the Fluormin-controlled Witkop property block, in the Groot Marico district of western North West province.

Regarding exploitation of the extensive Doornhoek dolomite-hosted stratiform mineralisation, an acidspar output of some 270,000 tpa, within three years of the commencement of operations, was tentatively referred to in publicity by the previous owner, CAMEC. However, though there has been no formal announcement of development, ENRC made it known that, from March 2012 onwards, it planned to initiate underground development, feasibility studies and design, with a view to a minimum mine life of 20 years, producing around 1.5m tpa of ore, which is equivalent to an acidspar output of about 240,000 tpa. This is the latest information placed in the public domain.

Additional to the VMC and Witkop output expansions, together with the specific possibilities considered above, many other situations of a more generalised and longer-term nature for additional contributions to output exist, again subject to consistent demand and attractive prices prevailing. These generalised situations are as outlined below:

Deposits of dolomite-hosted stratiform type, extensively developed in the Groot Marico district of western North West province, as exemplified by the Witkop and Doornhoek mineralisation.

Deposits genetically and spatially related variously to granite, felsite, leptite and comparable acidic/felsic rocks of the Lebowa Granite/Rashoop Granophyre suites at the top of the Bushveld Igneous Complex (BIC), within the central part of the intrusion's areal extent of over 60,000km², as exemplified by extensive vein stockworks formerly exploited for acidspar at the Buffalo, Zwartkloof and Stricker's operations, as well as the volcanic plug currently being exploited by VMC and the genetically related Nokeng mineralisation.

Deposits associated with satellite volcanic rock complexes of alkalic-carbonatitic type, postulated by South African Geological Survey experts to be genetically related to the BIC, as exemplified by strong fluorite mineralisation at such locations as Kruidfontein, Pilansberg and Roodeplaat, which are directly comparable with the Okorusu deposit exploited for acidspar by Solvay in Namibia.

Though the situations described above cannot entirely underwrite sufficient material being guaranteed to overcome the 2008 BGS report's assertions that "INEOS Fluor do not believe it [South African fluorspar] is available in sufficient quantities to meet their demands" and "the industry has serious doubts regarding the suitability or reliability of imports to meet English demand", they do illustrate that the pessimistic attitude manifested thereby is far from realistic.

The latter is emphasised by the maximum acidspar capacities quantified above, including the 440,000tpa of the two current or recently operational production establishments, amounting to over 1m tpa.

Regarding the quantification of South African resources/reserves available to support existing and increased production, company data are largely confidential, while insufficient exploration has been conducted to allow anything approaching a comprehensive assessment to be produced, but the potential is huge. Moreover, a guide is provided to the magnitude, solely in relation to the dolomite-hosted stratiform deposits, in a 1976 Department of Mines/Geological Survey publication, entitled *Mineral Resources of the Republic of South Africa* . This publication states that "The reserves at a lower limit of 15% fluorspar, located near the surface with little or no overburden, may be assessed at 80 to 100 million tons. If a lower grade ore (8-10%) could be processed economically, reserves might be several hundred million tons."

Metspar does not enter the equation as far as South African fluorspar exports are concerned since only a relatively limited amount is produced in the country for domestic consumption. Indeed, up to 5,000 tpa (in 2010) of Mexican metspar is currently imported. In relation to domestic acidspar consumption, Pelchem, a subsidiary of the South African Nuclear Energy Corporation (Necsa), has an HF production facility that could require about 50,000 tpa operated at maximum capacity, but the present utilisation is understood to require no more than 25,000 tpa. Therefore, the majority of acidspar output is available for export.

Breakdown of the data on South African acidspar exports reported for 2011 is presented in the accompanying table.

Other global fluorspar sources

Appropriate but necessarily brief and selective attention is given below to other actual and potential fluorspar import sources and related matters on a global basis, with concentration on acidspar, as well as projects likely to reach production within a time frame of 2-3 years, in view of the overall circumstances.

In addition to the need for brevity, coverage has been omitted of the sizeable producers - Brazil, Iran and Kazakhstan - as well as some smaller producers - comprising Argentina, Egypt, Kyrgyzstan, Pakistan, Romania and Tajikistan - in view of their current relatively insignificant impact on global supply and demand. For similar reasons, no consideration is given to substantial but currently unworked deposits reported to exist in Afghanistan, Mozambique and Zambia.

The attention given is intended not least in order to present fully the accurate situation concerning future supplies in the light of some misinformation publicised in recent times from various quarters.

Appropriate breakdown data on exports and/or imports reported for 2011 in relation to the various countries are presented in the accompanying tables respectively covering acidspar and metspar.

Australia has supported a small metspar output in the past, with about 70% coming from the Chillagoe district in northern Queensland, but it has never been an acidspar producer, though Comalco (now part of Rio Tinto Alcan) previously conducted a major exploration programme throughout the continent with the aim of reversing this situation. Additionally, there has been a great deal of promotional activity over the years, largely by Perth-based junior exploration companies, in relation to various properties concerning potential fluorspar production, but no development has been announced or appears to be imminent.

Bulgaria became an acidspar producer during 2009 when the Italian N&N Group established mining and processing operations near Chiprovtzi, in the northwest of the country. These facilities were acquired for captive/vertical integration purposes in early 2011 by Solvay, which then announced that it planned to increase acidspar production capacity from the original 30,000 to 50,000 tpa by the end of 2011.

Canada was reportedly scheduled to become an acidspar producer again in 2013 at a proposed rate of 120-180,000 tpa, by fulfilment of the Newspar 50:50 joint venture between Arkema and Canada Fluorspar Inc (CFI), based on the restoration of mining large vein deposits in the St Lawrence area of Newfoundland, using established but expanded processing facilities. In fact, the latest (March 2012) output referred to by CFI is approximately 126,000 tpa acidspar over a forecast 15-year mine life.

However, uncertainty was introduced by a CFI press release, dated 21 September 2012, announcing that a review of the project's scope and cost "is currently anticipated to be completed in the fourth quarter of 2012 or early in the first quarter of 2013. As a result of the review, the current expected commencement date for the construction of the project has yet to be determined. This comprehensive review is considering a range of mining and milling options".

In the meantime, without indigenous fluorspar output since 1990, Canada's acidspar requirements are satisfied by imports, reported as totalling 132,000 tonnes in 2011, while reported metspar imports amounted to 8,000 tonnes.

France has had no fluorspar output since 2006, due to Société Générale de Recherches et d'Exploitations Minières (Sogerem) ceasing production from its Montroc processing plant, reportedly as a result of reserves being exhausted. No current activity aimed at restoring indigenous acidspar production has been publicised, but possibilities with output potential exist. Such potential includes the suspended (1997) former Rossignol operations of Société Industrielle du Centre (SIC), near Chaillac, on the northwest flank of the Massif Central. Especially notable are extensive near-surface stratiform deposits, containing an estimated 17m tonnes averaging 35.6% CaF_2, located in proximity to the Morvan Regional Park, on the north flank of the Massif Central, between Beaune and Nevers.

The limited French requirements for acidspar were satisfied by reported imports of 6,000 tonnes in 2011, while reported metspar imports amounted to 9,000 tonnes.

Germany currently has an acidspar output of about 55,000 tpa from the Clara operations of Sachtleben at Oberwolfach, in the southern Black Forest. This amount is set to increase by

50,000 tpa in 2014, resultant upon the Phönix Fluss- und Schwerspat Bergwerk subsidiary of German fluorochemical producer, Fluorchemie, reactivating the reopening of a mine at Schobsetal, in the Ilmenau fluorspar district of the Thuringian Forest, with the activity being for captive/vertical integration purposes. Publicity has also appeared that, for the same purposes, consideration is being given to reopening the 25,000 tpa acidspar production operations of an original Bayer subsidiary, Fluss- und Schwerspatwerke Pförzheim, based on an extensive vein deposit at Käfersteige, in the northern Black Forest.

The country's very large acidspar requirements continued, in 2011, to be satisfied by imports, with a reported record of 308,000 tonnes, while reported metspar imports of 72,000 tonnes remained in the established pattern.

India has been a very small fluorspar producer since the commissioning in 1970 of a processing plant owned by the state-controlled Gujarat Mineral Development Corporation (GMDC). However, it was announced in early-2012 that the Gujarat Government had approved a joint venture between GMDC (50%), Gujarat Fluorochemicals (25%), and Navin Fluorine International (25%) to set up a fluorspar processing plant with a production capacity of 40,000 tpa. Though not specifically stated therein, the announcement presumably relates to acidspar production, particularly in view of the businesses of the junior joint-venture partners, both of which involve the manufacture of fluorochemicals.

The country has become a large consumer of acidspar, with reported imports of 194,000 tonnes in 2011, though there is a sizeable discrepancy between this quantity and the lower total of amounts reported as being supplied by the source countries, especially China. The same also applies to metspar imports of 21,000 tonnes reported for 2011, but to a greater extent in the opposite direction.

Italy has had no indigenous acidspar output since 2006 when Nuova Mineraria Silius ceased production. Notwithstanding this current status, major potential exists for the restoration of output, notably at various locations in Sardinia, where the production facilities of Nuova Mineraria Silius are understood to remain intact. Though having been a non-producer since 2006, the country has remained a major consumer, with 2011 requirements for acidspar satisfied by reported record imports of 212,000 tonnes, while reported metspar imports amounted to 35,000 tonnes.

Japan has had no reported fluorspar output since 1972 and even then the peak was only 21,000 tonnes in 1963. Thus, in continuation of the supply pattern that became well established in 2008-09, reported acidspar imports in 2011 amounted to 96,000 tonnes, as compared with a record 323,000 tonnes in 1989, while those for metspar totalled 126,000 tonnes, as compared with a record 386,000 tonnes in 1989. The implicit substantial import reductions are attributable to a large proportion of the primary added-value business being transferred from Japan to China.

Kenya has a single acidspar producer, the Kenya Fluorspar Company (KFC), whose nominal production capacity is 100,000 tpa, but which reported a 2011 output of over 117,000 tonnes. Furthermore, resources are available to support an even larger output, while de-bottlenecking of the processing plant was completed towards the end of March 2012 by the commissioning of an

additional ball mill in the grinding section to facilitate a 20% increase in ore throughput. Based on imports reported by the recipient countries, deduced acidspar exports for 2011 totalled 121,000 tonnes.

Mongolia is a growing source of fluorspar, notably acidspar for western markets, especially to the US and Germany, though its business is still largely orientated towards Russia, where the market is satisfied by so-called "acidspar" containing a minimum 92% CaF_2, rather than the international requirement of a minimum 97% CaF_2. A total of 154,000 tonnes has been tentatively deduced for acidspar exports in 2011, while the quantity derived for metspar exports is 156,000 tonnes, though actual amounts may be higher.

Morocco has a single acidspar producer, Société Anonyme d'Entreprises Minières (Samine), whose nominal production capacity is 120,000 tpa. However, output has been much lower than this capacity in recent times and progressively dropped from a 2005 level of 115,000 tonnes to 57,000 tonnes in 2008, due, reportedly, to adverse market conditions. This fall was followed by a steady recovery to 79,000 tonnes in 2011, so that some 40,000 tpa more is still available. Reported acidspar exports in 2009 and 2010 respectively amounted to 74,000 and 67,000 tonnes, but no export data have yet been reported for 2011, though a total of 58,000 tonnes can be very tentatively deduced from what may well be incomplete import data of recipient countries.

Namibia likewise has a single acidspar producer, Okorusu Fluorspar, the maximum reported output of which is 122,000 tonnes, reached in 2006. The current amount is understood to be about 80,000 tpa, and is evidently geared to the requirements of the vertically integrated fluorochemical production facilities in Europe of Solvay, which has wholly owned Okorusu since 1997. In fact, Solvay was the principal customer of Okorusu prior to acquisition, and so was aware beforehand of the unjustifably much maligned high P_2O_5 content of its acidspar product. Based on imports reported by the recipient countries, namely, Germany and Italy, acidspar exports for 2011 can be deduced with reasonable confidence as totalling 98,000 tonnes.

Norway may become a fluorspar producer again by the efforts of Tertiary Minerals, which are aimed at bringing the Lassedalen vein deposit into production at 100,000 tpa acidspar. However, the company has declared in an **IM** August 2012 interview that it will not be in production before 2016, so that the timing is beyond the scope of this consideration. Regarding the current status of the project, Tertiary has publicised a JORC-compliant inferred mineral resource of 4m tonnes grading 25% CaF_2, the successful completion of a Wardell Armstrong scoping study and related economic analysis, as well as further drilling plans.

Though having been a non-producer since 1956, and then only with small amounts of metspar, mainly from the Lassedalen deposit, Norway consumes up to 60,000 tpa acidspar in AlF_3 manufacture by Noralf. Such requirements are met by imports, normally from Morocco and South Africa, according to Noralf. The tentatively deduced acidspar import amount for 2011 is 50,000 tonnes.

Russia has a sizeable fluorspar output, estimated at about 250,000 tpa, with the main producer, at some 70-80% of the total, being Yaroslavsk GRK, which has been wholly owned since early-2012, for captive/vertical integration purposes, by United Company RUSAL, the world's largest

aluminium producer. Notwithstanding its sizeable output, Russia is far from self-sufficient concerning fluorspar supplies and has imported large quantities of acidspar and metspar for many years, mainly from Mongolia in recent times. Total imports of all grades are reported as 258,000 tonnes for 2011, regarding which the deduced apportionment between acidspar (including <97% CaF_2 content material) and metspar is shown in the accompanying tables.

Spain has a single acidspar producer, namely, Minerales y Productos Derivados SA (Minersa, now also referred to internally as MPD Fluorspar), which is based on extensive limestone-hosted stratiform and related deposits in and adjacent to the Asturias region of northern Spain. In fact, MPD now effectively controls all known fluorspar sources in the region, having progressively acquired the assets of former producers, including Fasa, Fluoritas Asturiana, Fluoruros, Minas de Arlos and Minas de Villabona. Nevertheless, despite evidently having the resources to do so, MPD has advised that there are no plans to increase output above its current level of 140,000 tpa acidspar and up to 10,000 tpa metspar.

Much of acidspar output is for captive/vertically integrated use by Derivados del Fluor (DDF). However, regular exports have been made to Canada in recent times, with imports by Canada from Spain reported as 25,000 and 24,000 tonnes respectively in 2009 and 2010, though the amount reported for 2011 is only 9,000 tonnes. Such exports by Spain are at least partly facilitated by Minersa importing limited quantities of acidspar from its VMC operations in South Africa, with the amount in 2011 reportedly 8,000 tonnes.

Sweden was a minor producer of by-product fluorspar flotation concentrates during the 1973-77 period. Moreover, during the early-1970s, with the aim of establishing sizeable acidspar production, the Granges Group investigated an occurrence near Storuman in which fluorite occurs as a cement in authigenic intergrowth with the silica and feldspar grains in an essentially flat-lying sandstone. Following a major programme of drilling, resource evaluation and metallurgical testwork, Granges abandoned the project in 1974.

An exploration licence covering the Storuman fluorite mineralisation was acquired by Tertiary Minerals in early-2008. Subsequently, Tertiary has regularly issued information about the progress of investigations, including plans for production of 100,000 tpa acidspar, but the timing at not before 2016 is again beyond the scope of this consideration. As to the project's current status, Tertiary has publicised a JORC-compliant mineral resource estimate of 27.8m tonnes averaging 10.2% CaF_2, the successful completion of a Scott Wilson multi-disciplinary scoping study, and the undertaking of a preliminary feasibility study.

Thailand was formerly a major fluorspar producer, with a record output of 427,000 tonnes in 1971, mainly comprising metspar, but including up to 75,000 tpa acidspar during the 1972-86 period. However, total output progressively fell, especially after 1985-6, to as low as 300 tonnes in 2005, at least partly due to Chinese competition. The possibility of acidspar production being restored has been raised by reports in 2009 that SC Mining was developing the Doi Ngom tungsten-antimony-fluorite deposit, near Chiangmai, in northern Thailand, and that a 50,000 tpa acidspar production plant was under construction.

In December 2011, Siam Emco Corp announced that it had taken over SC Mining and that the latter company produced "acid-grade calcium fluorite [*sic*]" in addition to tungsten and antimony concentrates. Thus, though reasonably positive, some uncertainty about complete fulfilment of the acidspar project exists in this specific case and needs to be confirmed.

Notwithstanding such uncertainty, based on first-hand field study, conducted on behalf of the Royal Thai Government under instructions from the United Nations, it is known that fluorspar deposits proliferate in various favourable geological environments down the country's western mountainous spine. Moreover, there are widespread dumps and tailings impoundment areas, which were accumulated during metspar production, and which contain very large but unquantified amounts of fine material constituting ideal feed for flotation processing to acidspar.

Tunisia was a significant acidspar producer at a rather variable 40-55,000 tpa until 1992, when the operations of Société Minière de Spath Fluor et Barytine (Fluobar) were terminated due to competition from imported Chinese and Moroccan supplies. Fluormin now holds a 35km² exploration permit embracing the former Hammam Zriba mine, which provided ore for the adjacent processing plant. A resource estimate of 4.8m tonnes grading 25% CaF_2 is quoted for the mine by the Government's Office National des Mines (ONM), but other occurrences of similar mineralisation in the favourable limestone environment also exist within the permit boundary. However, there is no news of production resuming.

Acidspar requirements of around 70,000 tpa for AlF_3 manufacture by Société Industries Chimiques du Fluor (ICF) have been satisfied by imports since 1992. Based on exports reported by supplying countries, deduced acidspar imports for 2011 total 73,000 tonnes.

UK fluorspar output ceased due to the closure of Glebe Mines at the end of 2010. During the latter part of Laporte's 1959-99 ownership of Glebe, reported acidspar output was consistently in a range of 65-70,000 tpa, while the maximum amount reported during the subsequent LRM/INEOS ownership was 56,000 tpa in 2003 and 2005, but there was a fall to 19,000 and 26,000 tonnes respectively for 2009 and 2010.

Shortfalls in consumption requirements from 2006-10 were covered by imports from South Africa and Spain, with a maximum of 21,000 tonnes reportedly supplied by the latter in 2006.

Regarding renewed output, further to its acquisition on 18 May 2012 of Glebe's assets, British Fluorspar has disclosed that it is planning to restart production operations in early-2013 with a minimum acidspar output target of 50,000 tpa. This newly formed company is related to the Italian HF and AlF_3 manufacturer, Fluorsid, as well as the Italian aqueous HF producer, ICIB, all through the Swiss-based Minmet Financing Company. Consequently, positive developments are awaited, in anticipation that the venture will be more successful than the related C.E. Giulini (Derbyshire) Limited, which was placed into voluntary liquidation during 1975 after operating for only four years.

As referred to above, UK acidspar requirements are being completely fulfilled by imports from Mexico. A total of 33,000 tonnes were imported in 2011, after an initial 10,000 tonnes in 2010, as verified by Mexican export statistics, in view of misclassification in UK import data. UK

metspar requirements, which amount to no more than 2,000 tpa, continue to be satisfied by imports from Mexico, mainly via Belgium.

US fluorspar output has been zero since the Ozark-Mahoning subsidiary of Elf Atochem (now incorporated into Arkema) ceased its acidspar mining and milling operations in southern Illinois during late-1995. Prior to this cessation, acidspar output had been in a range of 49-71,000 tpa since 1982, at which point output permanently dropped below 100,000 tpa, after peaking at 121,000 tonnes in 1972.

There is still no indigenous production, despite fluorspar deposits of varying significance being known in 15 states, namely, Alaska, Arizona, California, Idaho, Illinois, Kentucky, Montana, Nevada, New Mexico, Oregon, Tennessee, Texas, Utah, Washington and Wyoming. The most outstanding deposits are situated in the Illinois-Kentucky fluorspar district, from which the bulk of the country's acidspar output has historically come. In fact, the restoration of acidspar production from this district by Hastie Mining's exploitation of its Klondike II vein deposit, in western Kentucky, is expected during late-2012, with reference now being made by the US Geological Survey to an eventual production capacity of 200,000 tpa, as compared to the originally intended 50,000 tpa.

US acidspar requirements in 2011 were satisfied entirely by imports, as they have been since 1996, though the reported amount of 560,000 tonnes for 2011 differs significantly from the 493,000 tonnes deduced from exports reported by supplying countries. Notwithstanding this discrepancy, the US sourced more acidspar from Mexico than from China, in a progressively increasing proportion, for the fourth consecutive year in 2011, thereby returning Mexico to its position as the US's premier supplier, which it lost to China in 1991. Reported metspar imports for 2011 are 167,000 tonnes, entirely from Mexico, though the latter only reports 78,000 tonnes of exports to the US for the year. This, as yet, unexplained discrepancy and the similar one concerning acidspar are detailed in the accompanying tables.

Vietnam has been promising for 10 years to become an important acidspar producer by development of the Nui Phao polymetallic-fluorite greisen-skarn deposit, with the principal target product being tungsten concentrate, plus by-product or co-product outputs of bismuth, copper and gold, as well as acidspar. The deposit reportedly contains JORC-compliant ore reserves of 53m tonnes averaging 8.0% CaF_2, with ore resources amounting to 97m tonnes averaging 7.7% CaF_2.

Control of the Nui Phao deposit was acquired in 2010 by the Masan Group, one of Vietnam's largest private sector companies, and remarkably rapid progress towards production has been made since then, notably by employing the multinational ABB and Jacobs Engineering groups as main construction and supply contractors. In fact, Masan publicised in April 2012 that production is scheduled to commence in 2013, with the proposed marginal cost output of acidspar at a rate of 207,000 tpa.

Acidspar exports and imports 2011 ('000 tonnes)

Importer (data in red)	Exporter (data in black)									
	Mexico	China	South Africa[1]	Kenya	Namibia	Morocco	Mongolia	Spain	Others	Total
Canada	41	41	22							104
	44	58	21					9		132
France	2							1	3	6
Germany[2]	15	61	67							na
	23	77	75	45	69		19			308
India		103[3]	12	37[e]						152[e]
		138	15	37			1		3	194
Italy	88	15				27[e]				na
	92	24		39	29	27			1	212
Japan		72	7							na
		82	7				7			96
Norway			19			31[e]				50[e]
Russia		1					126[e][4]		1	128[e]
South Korea		6								6
		30					1			31
Spain			8							8
Tunisia	63		10							73
Turkey	1									na
	1								1	2
UAE			2							2
UK	33[5]									33[5]
									0.2[5]	0.2[5]
US	329	132	32							493
	401	119	39						1	560
Others	3	3								na
Total	573	433	179	121	98	58[e]	154[e]	10	na	na

(e) Estimated. na Not applicable/available.

(1) Data reconciled with that of recipient countries to eliminate anomalies, especially in relation to obvious misclassification of acidspar (HS code 252922) as metspar (HS code 252921) in South African statistics.

(2) Mainly via the Netherlands and/or Belgium.

(3) Partly via China, Hong Kong SAR.

(4) All at 92-95%, except for 200 tonnes at 97% CaF_2.

(5) Mexichem's multiple and extensive captive sources in Mexico are entirely and satisfactorily servicing UK acidspar requirements in terms of both quantity and quality, with supplies commencing in 2010 at 10,000 tonnes. UK import statistics do not reflect this situation accurately, due to the inexplicable misclassification of acidspar (HS code 252922) as metspar (HS code 252921).

Metspar exports and imports 2011 ('000 tones)	
Importer (data in red)	Exporter (data in black)

	Mexico	China	Mongolia	Namibia	Spain	Others	Total
Australia	1						1
Belgium[1]	130						130
	134	2				5[2]	141
Brazil	13						13
	19					1	20
Canada	8						8
Colombia	4						4
Ecuador	11						11
France	6	1			2		9
Germany[3]		28					na
	46	25				1	72
Guatemala	7						7
Honduras	2						2
India		70[4]					70
		13	2			6[5]	21
Italy	35						35
	35						35
Japan	96	32					128
	96	27	3				126
Malaysia		7					7
New Zealand		1					1
Panama	4						4
Peru	3						3
Philippines		2					2
Romania		2					2
		2				1	3
Russia		1					na
	1	1	128[e]				130[e]
South Africa	3						3
South Korea		78					78
	25	42	10			9[6]	86
Spain	7						7
Taiwan[7]		65					65
Trinidad and Tobago	1						1
Turkey	4						na
	19			4		23[8]	46
Ukraine	40						na
	28		13			1	42
UK	1						1
	45[9]						45
US	78						78
	167						167
Others	2	3					na
Total	439	289	156[e]	4	2	na	na

(e) Estimated. na Not applicable/available.

(1) Mexichem's Las Cuevas material shipped to a stockpile in Antwerp, from where distribution is effected to consumers, mainly in European countries, but also further afield. Belgian export statistics show shipments (in '000 tonnes) during 2011 were made to Germany (53), Turkey (15), Finland (13), Spain (8), France (6), Sweden (5), Poland (4), South Africa (4), Egypt (2), Bosnia (1.5), the UK (1.5), Luxembourg (1), and eight other countries at less than 0.7 each, though with the amount often much less.

(2) Evidently mainly re-export of imports by Germany and the Czech Republic.

(3) Mainly via the Netherlands.

(4) Partly via China, Hong Kong SAR.

(5) Shipments (in '000 tonnes) from Thailand (3.7), Pakistan (1.4), Iran (0.5), and eight other countries at less than 0.3 each, though with the amount usually much less.

(6) Shipments (in '000 tonnes) esssentially comprising re-export of imports by Japan (6) and output from Thailand (3).

(7) Reported as Other Asia,nes, which is the current UN Comtrade data concealment code for Taiwan.

(8) Shipments (in '000 tonnes) comprising output from Iran (18), re-export of imports by Italy (4.2), and material from three other countries at less than 0.3 each.

(9) UK import statistics grossly inflated, evidently by including acidspar (HS code 252922) shipments of 43,000 tonnes (10,000 and 33,000 tonnes made respectively in 2010 and 2011) from Mexico misclassified as metspar (HS code 252921), particularly bearing in mind that UK metspar supplies from Mexico, normally via Belgium, are usually less than 2,000 tpa.

The question answered

The question about whether significant fluorspar imports are a realistic option can only be answered with an emphatic affirmative in view of the numerous examples of this being the case presented above. Moreover, overwhelming evidence has been presented in outline to demonstrate that adequate resources exist and that these are being developed, or are developable, to satisfy foreseeable global fluorspar requirements. Market forces will clearly have a critical influence in ensuring that adequate supplies remain available, with this meaning a prevailing climate of consistent consumer demand and attractive prices as incentives.

In fact, the overview demonstrates that potential exists around the world for major additional output of acidspar, which is already available in underused or idle installed capacity, plus planned projects with reasonable confidence that they will materialise. In addition, there are other promoted projects of more uncertain likelihood of being fulfilled.

This does not necessarily mean that periods of tight supply will not arise in future, as they have done in the past due to the cyclical nature of the minerals industry as a whole, because of supply and demand fluctuations governed by the world economy and related factors. However, what must be avoided as far as possible is a major over-supply situation, as has happened on previous occasions, in view of the associated inevitable price erosion and producer casualties.

Chinese dumping

It appears to have been widely overlooked that a seriously adverse impact on supplies from elsewhere in the world arose entirely due to very large quantities of Chinese fluorspar, initially at extremely low prices, being flooded on to global markets from the mid-1980s, while Japan was affected as early as the late-1970s. Furthermore, though Chinese prices eventually increased

substantially, the very large supply quantities continued throughout the 1990s into the 2000s. This involved peak fluorspar exports from China of 1.322m tonnes in 1998 and, though there was a fall to 269,000 tonnes in 2009, the amount recovered to 722,000 tonnes in 2011, for which grade breakdown and related details are given above in the section covering China, as well as pertinent references in the other country sections and data shown in the accompanying tables.

Bearing in mind that analysis of the situation does not indicate it will happen soon, or in the foreseeable future, the retreat or even withdrawal of China from the global fluorspar supply scene is considered as unlikely to prove anything like as detrimental, if at all, as some doomsters would have it.

Nevertheless, the withdrawal of China as a major player could prove beneficial ultimately in stabilising the supply-demand situation. This particularly relates to markets becoming available, accompanied by reasonably high and stable prices, thereby rendering viable or improving the viability of production operations elsewhere in the world, bearing in mind that all were adversely impacted to varying extents, including a number being driven out of business, when large quantities of cheap Chinese material were flooded on to global markets.

As to the availability of attractive prices required to drive increased output, it is illuminating to review the price history for Chinese acidspar supplies, as summarised in the accompanying idealised graph. This shows that the CIF US Gulf ports and Rotterdam price, as bulk filtercake on a dry weight basis, was at an annual average of about $90/tonne in 1987, which was equivalent to a price of less than $70/tonne FOB Chinese port. Furthermore, the graph depicts current **IM** price ranges of $480-600/tonne CIF US Gulf ports and $500-530/tonne CIF Rotterdam, which are reportedly equivalent to a price range of $420-440/tonne FOB Chinese port.

Incidentally, regarding the especially damaging and disruptive impact of large quantities of low-priced Chinese acidspar entering global markets in the mid-1980s and continuing into the 1990s, it is appropriate to recall that this eventually resulted in the European Union (EU) statutorily imposing a substantial anti-dumping duty on imports of Chinese acidspar, with effect from 4 March 1994. Such legislation remained in force until it was allowed to expire on 27 September 2005, by which time the price for Chinese imports had well exceeded the minimum level of €113.50/tonne (then about $128/tonne) at the EU frontier, at which the duty came into force, so that it had become pointless.

For comparative purposes in relation to current prices, Mexican acidspar, as bulk filtercake on a dry weight basis, has a published range for <5ppm As material of $540-550/tonne FOB Tampico, while the range for standard material is $400-450/tonne FOB Tampico. Furthermore, South African acidspar, on the same basis, has a current published price range of $380-450/tonne FOB Durban, after being increased to this level from $330-335 in January 2012. However, Fluormin revealed in its *Interim report for the six months ended 31 December 2011*, issued on 30 March 2012, that an average of $429/tonne had been obtained during the 2011 second half, while an average of $472/tonne was reported for a reduced amount shipped in the first quarter of 2012.

It is also appropriate to record that prices for metspar have escalated substantially over the years. Thus, from a 1987 low of $50/tonne FOB Tampico, the current reported price range for Mexican metspar, bulk, 80-90% CaF_2, is $230-270/tonne FOB Tampico. This is comparable with a published but questionably high price range for similar material of $305-385/tonne FOB China.

Despite no long-term global fluorspar supply shortage being expected, this does not mean that periods of tight supply will not arise in future, as already referred to above. Thus, similar to what has happened in the past, such episodes are likely to arise due to the cyclical nature of the minerals industry and related factors. Furthermore, varying extended degrees of time-lag may arise in new supply sources becoming available to replace those that disappear for one reason or another, particularly if consumers place excessive downward pressure on prices.

However, there should be no serious supply shortages providing a pragmatically sensible and ongoing rapport is established regarding reasonable prices between consumers and producers. Bearing in mind the unsurprising breakdown of such a rapport when cheap Chinese supplies in large quantities entered global markets, such a relationship is essential in order to ensure adequate future supplies on a relatively regular basis. The required natural resources certainly exist, but they have to be converted into economic reserves by promising to be sufficiently profitable to attract the required investment and effort needed to justify exploitation. Otherwise, the boom-and-bust consequences manifested on several occasions previously to greater or lesser extents will inevitably recur - in neither side's best interests.

Dr Brian Hodge *, CEng FIMMM CGeol FGS, has been involved with the global fluorspar industry in various capacities for over half a century, commencing with introduction to the speciality while undertaking PhD field studies during the 1950s in the UK's Northern Pennine Orefield, under the supervision of Professor Sir Kingsley Dunham FRS. He subsequently joined Laporte as Group Geologist, with particular responsibility for investigations relating to the assessment and development of the extensive fluorspar properties held by Glebe Mines in Derbyshire, UK, notably on Longstone Edge, where the new Sallet Hole Mine was brought into production in 1965. Secondment was then effected to be Production Manager and Acting Works Engineer at the Glebe Mines subsidiary, with responsibility for all mineral processing and related operations, including completion, full commissioning, and expansion of the Cavendish Mill, starting at the time of its official opening.*

In a natural progression from undertaking independent assignments, an eponymous consulting partnership was formally set up during 1974, notably in conjunction with Frank Robinson, who established Glebe Mines in 1941 and was its Managing Director until promoted within Laporte in 1965. Though not restricted to such activity, the consulting practice specialised on fluorspar, with global assignments undertaken for a broad range of clients, variously comprising accountants, banks, lawyers, individuals, major companies, local authorities, governments and international agencies.

Dr Hodge last contributed a major article on fluorspar to IM in 1973, but, in

addition to similar activity for other organisations, he variously gave presentations at and/or acted as chairman of IM conferences relating to fluorspar, with the current annual fluorspar conferences stemming from a session on the commodity chaired by him at the Sixth IM International Congress in 1984. Regarding other publications, especially notable are articles on the global fluorspar scene contributed to the Mining Annual Review journal for 31 consecutive years prior to 1999, when the task was relinquished shortly before retirement. This article relies on continuing avocational interest in the speciality, drawing on a large and wide-ranging database regularly updated by company press releases, publications, and long-established global contacts in industry and government, with the ongoing invaluable assistance of such contacts hereby gratefully acknowledged.