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Executive Summary

This report was compiled by CSIR Implementation Unit in terms of its appointment by the Department of Mineral Resources (DMR) as Accredited Testing Authority (ATA). It reviews the general status of self-contained self-rescuers (SCSRs) deployed in the South African mining industry for the period 1 January - 31 December 2015. The report includes performance analysis and trends of SCSR capacity as a function of age. An aspect that should be fundamental in establishing mine escape and rescue strategies. The report also identifies the commitment levels of the different mines/shafts taking part in the on-going monitoring programme, and comments on their infrastructures, specifically with regard to SCSR maintenance levels, control, record keeping and user training. The level of compliance with legislation (Regulation/Chapter 16.2, 16.3 and 16.4 of the Mine Health and Safety Act) is indicated using a categorisation system (Compliance levels 1 – 3). A summary of the findings and an analysis of trends are given on pages 27 to 29.

The most relevant findings are summarised as follows.

1. Over recent years (2011-2015) the number of mines/shafts deploying SCSRs appears to have stabilised at about 200 operations. A similar observation that also applies to the number of SCSRs in use, viz. about 220 000 units are currently deployed. This data is of relevance not only with respect to mines' infrastructures required to monitor the structural integrity of units in daily use but also to the capacity of the SCSR monitoring programme. The implications are discussed in Section 3.1 of this report.
2. Outright failure of units, as determined by breathing simulator tests and structural tests, has not exceeded the 0,3 % level, the 2015 data reflected in this report being 0,23 %. This failure rate exhibits a 50% decline since the 2012.
3. There are two areas of general concern, namely protective casing leakage and self-ignition of units (Section 3.2). Protective casing leakage reduces the SCSR oxygen generation capacity, therefore, has direct effect to escape travel distances, layout of escape routes and the location of safe places. Self-ignition of units has the potential to

trigger major incidents affecting the safety and health of underground personnel at any location in the mine.

4. The occurrence in leakages of protective casings has nevertheless shown a sharp decrease from 9.3% in 2014 to 0.4% in 2015 (Section 3.2). Among others, the protective casing modifications performed on the Roxy40 SCSRs has added value to the unit sealing mechanism, therefore, reduced the number of leaking units (See Section 3.2.4). All the protective casing modifications were approved by the TTC before been implemented.
5. As in the past, SCSR leak tests are still based on divergent methodologies. This makes an objective and equitable assessment of actual leakage rates impossible to assess. Most notably this impacts the quantification of functional performance and life-saving potential using similar benchmarks. This issue is presently under discussion with the Tripartite Technical Committee (TTC) and the SABS (Section 3.2).
6. Of the individual SCSR units evaluated (Section 3.2), the majority of MSA/SavOx units that were manufactured prior to 2008 performed poorly. The affected mines were notified about this issue and advised to review their escape strategies accordingly. This could compromise in many cases a successful escape from irrespirable atmosphere in case of an underground fire and may well have a significant impact on escape strategies, notably the positioning of safe places or location of cache facilities along the escape route.

7. The general standard of SCSR maintenance, control and record-keeping shows a continuing decline (see Table 6). The reason for the decline is ascribable to a consistent shift from being unable to maintain Compliance Level 1 standards and a steady increase in the number of operations achieving only Compliance level 3 standards, i.e. mines or shafts with ‘insufficient’ standards.

These trends are discernible over the period 2008 – 2014 (inclusive) and suggest that at present underground workers at 23 mines or shafts (i.e. 15.68% of mines/shafts visited in 2015), may be subjected to unnecessary risk. The impact of the continued trend in compliance deterioration will manifest itself more markedly in the future as the newly deployed SCSRs (over 100 000) will age.

The overall perspective as summarised in the present report is consistent with previous ones:

Generally, the deployment of SCSRs in the South African mining industry still complies with and, in some aspects, exceeds local and most international requirements. This represents still a remarkable achievement given the extent of operations, the size of the labour force at risk, and conditions to which many SCSRs are subjected during daily underground deployment. However, based on the findings of the 2015 monitoring programme it is eminently clear that the risk of malfunctioning SCSRs should not be underestimated and efforts to reduce this, irrespective of origin, should be subjected to critical review.

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1. Introduction

Self-Contained Self-Rescuer Testing Facility, Johannesburg, South Africa

The primary purpose of this report is to provide feedback to all interested and affected parties (both national and international) on the functional status of formally approved Self-Contained Self-Rescuers (SCSRs) and currently deployed in the South African mining industry. The period of review is January to December 2015. The make and types of SCSRs reviewed in this report are:

- AfroxPac35 (South Africa),
- AfroxPac35i (South Africa),
- Draeger Oxyboks K35 (Germany),
- MSA / SavOx (Germany),
- Roxy-40 (Ukraine).

2. Methodology

Sampling of SCSRs for functional performance evaluation was done in accordance with the Mine Health and Safety Act (MHS Act) of 1996, Regulation 16.4(1). In terms of this Regulation, a sample of at least 1 % of the total units deployed at a mine must be selected and withdrawn by the ATA annually for functional performance evaluation. In some cases sample larger than 1 % were drawn from mines/shafts that still deploy older units in order to increase the level of accuracy on the performance assessment of these ageing units.

Prior to September 2002, functional performance and structural testing of SCSRs were conducted according to the South African Bureau of Standards (SABS) Private Specification 839 (CKM) and thereafter in accordance with the South African National Standard (SANS) 1737 Specification.

Leak testing, which forms part of the structural assessment, is presently conducted by means of an electronic negative pressure leak detector, prior to opening the protective casing of the unit for the functional performance test.

Functional performance is assessed using mechanical lung function simulators. The simulator test provides an objective, reproducible parallel to human breathing in that the breathing cycle is mechanically simulated and electronically controlled with respect to tidal volume and breathing rate. In addition the exhaled air is enriched with carbon dioxide, humidified and heated to body temperature (37°C).

Structural testing, after completion of the functional performance test, consists of an evaluation of the mechanical condition of selected SCSR components, i.e., mouthpiece, nose clip, breathing tube, neck strap (head strap and waist strap where applicable), pressure relief valve and breathing bag.

For the purposes of the monitoring programme, the lung function simulator tests are performed at a ventilation rate of 35 litres / minute. This ventilation rate is in accordance with SANS1737:2008 Specification and in a general sense can be equated physiologically to a 'moderate rate' of exertion, i.e. the demand likely to be encountered when negotiating horizontal escape routes with no ceiling restrictions. The positioning of places of safety, e.g. SCSR caches and refuge bays, should not only be inferred from breathing simulator test results but also from mine-specific trials (see Section 3.2, paragraph 2).

Functional performance of units submitted for assessment was categorised in accordance with the original Government Mining Engineer Guideline 16/2/9:

Category 1: Functional performance does not conform to compliance test specifications for new units but, nevertheless, does not exceed rejection limits; in this respect the life-saving potential of such units is deemed to be unimpaired.

Category 2: Major material/structural faults or functional performance has deteriorated beyond the rejection limit, with a safe functional duration of less than 15 minutes; survival is deemed to be jeopardised should the unit be used in the normal escape mode.

3. Results and Discussion

3.1 Distribution statistics

Over the past three years, the number of tested units is almost stagnant and in total, 2 186 units were tested during the current reporting period. A comparison with the previous four years is given below.

- 2011: 2 117 units from 200 mines/shafts
- 2012: 2 060 units from 202 mines/shafts
- 2013: 2 183 units from 198 mines/shafts
- 2014: 2 183 units from 201 mines/shafts
- 2015: 2 186 units from 185 mines/shafts

The general impression is that a steady-state has been reached with respect to the number of units tested. The variation in the number of mines visited corresponds to the mines / shafts which are currently on care and maintenance and / or closed. Inasmuch as these trends have a pronounced impact on the logistics of SCSR monitoring, it follows that they should be subjected to on-going review by the DMR and TTC.

In terms of an instruction issued by the Chief Inspector of Mines (Reference 24/4/8, dated 2 November 2005), no SCSR older than ten years shall be deployed or used in the South African mining industry with effect from 1 January 2007.

The number of samples representative of the five approved SCSR types deployed in South Africa in 2015 is given in Table 1.

Table 1: Distribution of SCSRs tested by trade name

Manufacturer	Tested (n)	Approximate % of units deployed on all mines for a period exceeding one year
AfroxPac35	743	34
AfroxPac35i	820	37
Draeger Oxyboks K35	379	17
Roxy40	209	10
MSA / SavOx	35	2

The distribution of SCSR units tested per commodity mined, as well as the respective number of mines (in some instances defined as specific business units or shafts or, in other instances, as a group of shafts), is summarised in Table 2.

Table 2: Distribution of SCSRs tested by commodity

Commodity	Units tested (n)	Mines (n)
Gold	830 (*83 000)	43
Coal	318 (*32 000)	49
Others, i.e. Cu, Mn, Cr	212 (*22 000)	31
Diamond	68 (*7 000)	7
Platinum	758 (*76 000)	55
TOTAL	**2 186 (*220 000)**	**185**

**** Approximate total number of SCSRs deployed underground for a period exceeding one year***

The data presented reflects the extent of labour-intensive mining activities in the gold and platinum sector. Deployment trends by commodity are summarised in Table 3.

Table 3: SCSR deployment trends

Period	**Mines/shafts** (n)	**SCSR deployed by commodity** (n)					**Total (SCSRs)** (n)
		Gold	**Coal**	**Platinum**	**Diamond**	**Other**	
2005[1]	150	75 000	28 000	40 000	4 000	6 000	**153 000**
2011[1]	200	90 000	30 000	61 000	2 000	17 000	**200 000**
2012[1]	202	80 000	30 000	66 000	2 000	22 000	**220 000**
2013[1]	198	85 000	30 000	74 000	3 000	28 000	**220 000**
2014[1]	201	90 000	30 000	67 000	3 000	30 000	**220 000**
2015	185	83 000	32 000	76 000	7 000	22 000	**220 000**
Change	**+ 35**	**+ 20%**	**+ 7%**	**+ 68%**	**+ 75%**	**+ 400%**	**+ 44%**

[1]See ‘Annual Reports of 2005 2011, 2012, 2013 and 2014 respectively.

Note 1: The above data are based on extrapolations of the number of units assessed.

Note 2: The period 2006-2010 (inclusive) has been omitted for convenience; explanatory notes appear in the text and further details are included in Table 5.

The overview presented in Table 3 depicts increase of the SCSRs deployment at all commodities except gold and coal mines over a ten year period. The marked increase in SCSRs deployed in the platinum sector is influenced by deployment of the SCSR units, at all underground operations of Impala Platinum Mines since 2013/14.

As can be seen from Table 4 there are also logistic challenges: The relatively high number of SCSRs deployed per operational unit suggests that gold and platinum mines have to cope with distribution and primary control and monitoring infrastructures that are or are coming under severe pressure. Collectively, these trends, if allowed to escalate, are likely to pose a threat to the functional reliability of SCSRs.

Table 4: Ratio of SCSRs deployed / operational unit

Review period	SCSRs deployed per operational unit			
	Gold	Coal	Platinum, Diamonds, others	Combined Industry
2000	397	347	139	744
2010	1 809	472	1 130	1 011
2011	1 698	508	1 151	1 000
2012	1 860	491	1 200	990
2013	1 848	455	1 510	1 111
2014	1 915	462	1 396	1 095
2015	1 930	653	1 129	1 189

It follows that with a steady increase in the number of SCSRs deployed, the logistical challenges will also extend to the SCSR monitoring programme (Table 5).

Table 5: Number of SCSRs tested by the ATA: 2000-2015[1]

YEAR	Commodity					Total
	Gold	Coal	Diamond	Platinum	Other	
2000	397	347	–	–	139	**883**
2010	852	293	34	645	140	**1 964**
2011	933	304	28	672	181	**2 118**
2012	755	317	32	728	228	**2 060**
2013	897	357	26	666	237	**2 183**
2014	877	356	15	666	269	**2 183**
2015	830	318	68	758	212	**2 186**

[1]*The number of units tested represent (or is as close to) 1 % of the estimated number of SCSRs deployed. The year 2000 is included to provide a comparative reference*.

3.2 Structural integrity and performance trends

The data and findings from the 2015 annual monitoring programme indicate a need to improve the overall effectiveness of SCSR usage to ensure maximum life saving potential at all times. Therefore the TTC should consider taking the initiative in establishing a process of critical reviews and auditing through existing industry structures such as CSIR, DMR and GEEs . The findings presented here tend to provide support for such an initiative. There are two areas of general concern, i.e. leakage of protective casings and self-ignition of units.

During the current reporting period the incidence of protective casing leakage exhibited a major reduction compared to the previous year. Although there was already a sharp decline in 2014, the results in 2015 have shown a further decline in casing leakage to 0.4% (i.e. 8 SCSR units) of all units tested. As stated in the 2014 annual report, the reduction in casing leakage is a positive trend. This could be attributed to a more diligent in-house leak testing programme adopted by many mines, an in many instances an increase in formal maintenance service contracts between the mines and the suppliers. This is likely to result in a longer service life of SCSRs in the medium to long term and also lead to cost savings and enhanced standards. However, since the calculation of escape routes, inclusive of the positioning of refuge bays, is based extensively on the safe functional performance potential of SCSRs, it follows that the element of risk introduced by leakage of protective casings cannot be underestimated or ignored. Therefore the escape route layout and location of refuge bays should be based on actual SCSR performance results obtained from the functional performance monitoring programme. The extent to which differences in leak test methods have a bearing on the above findings can only be surmised. For example, whereas Draeger and DZGA/Ukraine prefer the use of positive pressure leak testing, the CSIR, MSA and Afrox apply a negative pressure leak detection method. It is of the utmost importance that a uniform test method is agreed upon to ensure consistency.

The official leak test compliance parameters of SANS 1737:2008 require that units remain leak tight when exposed to a 45°C water bath, i.e. no bubbles should be visible after 5 minutes. The industry acknowledges the potential risk associated with exposure of potassium superoxide (KO_2) and water; hence, alternative protective casing leak test methods are encouraged. The widely accepted industry practices for casing leakage testing are the positive and negative pressure differential methodologies. Since, the negative pressure leak test at -70 mbar (7 KPa) is comparable to and correlates with the test stipulated in SANS 1737:2008. The TTC has submitted the proposal to the SABS to revise *“leak-tightness of the protective casing”* and *“hydrostatic pressure test”* methodologies in order to align with the accepted practice(s).

Secondly, the potential for ignition due to heat over-exposure remains a real risk and to this end numerous units of the affected SCSR type were modified during 2009 to obviate this. Although, the problem has not been entirely eliminated, the risk of ignition appears to have decreased. However, with the large number of these units still in daily underground use, the problem remains a statistical reality. Therefore, a recommendation was made by the TTC in 2015 that all AfroxPac35 units, which are five years and older be removed from underground deployment. The programme for removal of the affected SCSR type has been initiated by the Original Equipment Manufacturer (OEM) and it is quite obvious that the progress of SCSRs removal is dependent on the allocated resources from the mining companies. Inasmuch as the TTC recommendation is still voluntary, a potential risk remains.

The development of the CSIR's 'ECO OWL', as reported in the 2014 annual review is in abeyance due to a number of technical challenges including humidity measurements inconsistency in various units. It was anticipated that by the end of 2016, the roll-out of the devices would have taken effect. Alternative approaches with similar objectives are being explored to realize the successful implementation of this device.

The device is meant to monitor heat and humidity levels inside the protective casing continuously and would be able to alert the SCSR wearer and lamp room personnel of any unit exposed to excessive external heat and/or leakage of the protective casing. Faulty units would therefore not be taken underground. The use of the 'ECO-OWL' could reduce the frequency of SCSR leak testing and provide a clearly visible indication of an impending malfunction. Therefore, the benefits with respect to safety and the cost associated with the maintenance and repair of SCSRs should be apparent.

A discussion of the findings for each of the respective SCSR unit types tested is given below.

3.2.1 MSA/SavOx

The MSA/SavOx units have now been deployed in the South African mining industry since 2005. Of the 35 units tested, only 10 performed satisfactorily with functional test durations in excess of 30 minutes being recorded. In the majority of units manufactured or assembled prior to 2008, significant deterioration in functional performance was observed due to premature increases in breathing resistance. This effectively reduced the safe functional duration in some of these units significantly.

Outer casing: Front view

Outer casing: Rear view

Inner unit

3.2.2 Draeger Oxyboks K 35

The Draeger Oxyboks K35 has now been deployed in the South African mining industry since 2005.

The unit has a 25 minutes rated functional duration. For this reporting period, 379 units were tested. 324 out of 379 units performed between 25 and 30 minutes with a further 52 units performing in excess of 30 minutes. Only three units performed marginally lower than the officially rated functional duration.

The Kevlar cover over the outer protective casing, as was reported at the introduction of the unit in 2005, still remains a problem. Although designed to act as a shock absorber and to provide added protection to the unit, the cover itself is susceptible to major abrasion, especially in hard-rock mines. Moreover, there are ergonomic issues to consider, notably with respect to the added bulk of the unit and, in some instances, difficulties in attaching units to certain types of waist belts. Furthermore, not all storage racks used in mines' lamp-rooms are compatible with these units, thus requiring extensive and costly modification.

Outer casing: Front view

Outer casing: Rear view

Inner unit

3.2.3 AfroxPac

3.2.3.1 AfroxPac 35

The AfroxPac35 has been deployed in the South African mining industry since 2002. The majority of the units performed satisfactorily with functional performance durations exceeding 35 minutes. However, older units, i.e. manufactured prior to 2008, display premature but as yet not critically elevated carbon dioxide inhalation levels after approximately 30 minutes. Functional performance deterioration occurs mainly as a result of normal wear due to the age of many of these units, and the subsequent powderisation of the chemical. Of the 743 units tested, 656 units performed satisfactorily with functional test durations of above 30 minutes being recorded. No unit performed less than 15 minutes.

Three unit failures were observed in this reporting period. Namely in one unit due to heat damage to the breathing bag, another unit exhibited fire damage to the breathing bag and an ignition during functional performance testing occurred in the third unit.

Outer casing: Front view

Outer casing: Rear view

Inner unit

3.2.3.2 AfroxPac 35i

The AfroxPac35i units have been deployed in South African mines since early 2013. Of the 820 units tested in 2015, 816 units performed satisfactorily with functional test durations of above 30 minutes being recorded. Three units performed between 25 minutes and 30 minutes.

In one unit a failure was observed. The unit exhibited a faulty pressure relief valve and as a result, this unit could not be functional performance tested.

Outer casing: Front view

Outer casing: Rear view

Inner unit

3.2.4 Roxy-40

Roxy-40 SCSR units have been deployed in South African mines since early 2012. The 209 units tested in 2015 performed satisfactorily with functional test durations of above 30 minutes being recorded in all units. Although, in many units, specifically those deployed in hard-rock mines, major abrasion to the protective casing is observed.

In 2014, 19,3 % of the tested units exhibited casing leakage whereas in the current reporting period, all units passed the casing leakage test. This observation could be attributed to more regular maintenance service contracts being entered into between the OEM / supplier and the mines.

Outer casing: Front view

Outer casing: Rear view

Inner unit

3.3 Compliance with legislation

Participating mines were rated according to the categorisation system stipulated in Regulation 16. The findings, in conjunction with those of previous years, are shown in Table 6.
A summation of Levels 1 and 2, as an overall criterion of ‘satisfactory compliance’ with legislation, presently stands at 87,6 % which, although at face value, seems to be acceptable. However, the negative trend continues and the compliance percentage of approximately 88% is similar to those observed in 2007 and 1999 (see Table 6).

It is obvious that the emphasis of the above finding should fall on the corollary, i.e. the increase in mines (or operating units) that do not comply with these requirements.

The rather elementary analysis presented above suggests that these findings are not due to 'chance variation' and that the underlying reasons warrant urgent investigation of the mines concerned to avert a possible further downward trend.

Collectively the above conclusions suggest in no uncertain terms that a substantial part of the underground labour force may well be exposed to an unnecessary but entirely preventable risk.

Against this background, and in the light of previous recommendations (Schreiber et al, 2007; 2008; 2009; 2010; 2011; 2012 2013 and 2014), the proposal still stands that,

(a) **transgressing mines (operational units) be investigated by the DMR** with the stated objective of achieving an improvement in compliance status (Sections 4.5 and 4.7), and
(b) **the reasons for the consistent and worsening imbalance between Level 1 and Level 2 compliance achievements are investigated by the DMR (**Section 4.5).

Table 6: Industry compliance with Regulation 16 of the Mine Health and Safety Act

Category[1] (compliance level)	Year									
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1: (n) %	57 37	55 33	70 40	69 40	68 37	60 30	57 29	40 20	30 15	12 6,5
2: (n) %	93 61	90 55	89 51	97 56	109 60	133 67	133 66	135 70	142 71	150 81,1
1+2(%)	98	88	91	96	97	97	95	91	86	87,6
3: (n) %	3 2	20 12	14 9	7 4	6 3	7 3,5	10 5	19 10	29 14	23 12,4
Total (n)	153	165	173	173	183	200	202	198	201	185

[1]*Compliance with Regulation 16 of the Mine Health and Safety Act*

1: 'exceeds requirements'

2: 'meets requirements'

3: 'insufficient standards'; non-compliance'

(n): mines/shafts (i.e. operational units)

The reduction in mines/shafts visited in 2015 compared to 2014 (7,96%), is mainly related to the present economic situation in the mining industry and possible other unknown factors.

3.4 Batch testing

Batch testing was introduced prior to the introduction of SANS 1737 on the basis of a recommendation raised in 1999 (Schreiber et al, 1999).

Batch testing requires that a small sample of presently approved new units, prior to being delivered to the mines, be selected by the ATA from the OEM and tested for leakage of the protective casing, as well as for functional performance on the breathing simulator.

This provides the end-user with a reference/benchmark on how new units perform before deployment underground and enables a measure of the actual rate of functional deterioration against this reference/benchmark subsequent to deployment.

In the ATA's experience, even a careful external and internal inspection of SCSRs in many cases would be insufficient to identify functional failures other than obvious material or assembly defects, mostly due to poor quality control by the OEM.

Where SCSR malfunctioning is evident, batch testing identifies the most likely origin (source), distinguishing between the OEM (i.e. as a result of poor quality control) and the end-user (e.g. as a result of wear-and-tear or even of deliberate SCSR abuse).

Although the OEMs conform in most cases to this requirement, some irregularities were observed during this reporting period. It is therefore crucial for the end-users to insist on batch approval documentation upon delivery of the new units and the OEMs must proactively provide such documentation.

As reported in 2014, the failure rate on batch approval testing in accordance with SANS 1737:2008 remains at approximately 0,4%. Reduced functional durations of new units have been observed from more than one OEM. Currently, the CSIR is in the process to establish the cause of some of these problems.

A general observation is that the number of batch testing performed during 2015 has seen a significant reduction when compared to previous years. This is mainly related to the

MSA/Savox unit and correlates with the reduction of this type of unit deployed in the SA mining industry (see Table 1).

4. Conclusions

4.1 SCSR monitoring: a general perspective

As was observed during the last two decades, international trends show a clear preference for chemical-based SCSRs and the rationale for a purpose-developed SCSR monitoring programme has been the subject of a critical review (Schreiber and Kielblock, 2000 and 2004). However, functional performance monitoring is based on statistical predictions and data analyses derived from destructive test protocols of a limited sample of units. Therefore, the fact that the life-saving potential of SCSRs in daily use relies extensively on 'predictions' that are not based on the age of the units being tested is quite obviously, a weakness. It is suggested that the units selection procedure be reviewed.

Although the focus of this report falls on SCSR functional performance, the data generated as a matter of course also provides the basis for strategic review, as would be apparent from Section 3 of this report.

The following considerations are relevant.

- South African deep-level mines in terms of hard-rock abrasion, daily, depth-induced barometric pressure fluctuations and high environmental heat and humidity extremes, probably pose the most severe challenge to the structural integrity of SCSRs. These considerations in conjunction with the size of the labour force at risk, suggest that there would be considerable merit in conducting a critical review of the structural integrity of the current range of SCSRs and exploring avenues for further improvement. The CSIR is well-placed to undertake a project of this nature and, apart from the obvious potential benefit to Industry, the information thus obtained serves to enhance the relevance of the SCSR monitoring programme.
- Indications are that mines' infrastructures to support SCSR readiness on a daily basis are, if anything, under logistical pressure and under resourced (Section 4.5). These infrastructures represent a 'first line of defence', yet there are **presently** no formal standards and guidelines to assist mines in this regard.
- Lamproom compliance with Regulation 16 is inadequate in a number of instances. The reasons for this should be established and the compliance process revised. Clearly, this

should be a DMR initiative but to achieve such objectives it would be essential to draw on available expertise (i.e. CSIR, TTC and the mining industry).. The point is to ensure that compliance directives are practicable and meaningful. Under circumstances where non-compliance persists, the DMR should act accordingly.

- The potential impact of a steady escalation in SCSR deployment on the capacity of the SCSR monitoring programme should be subjected to on-going review. Such reviews by the TTC should also be extended to the relevance of current methodology for sample selection.
- **Innovations to improve assessments of the structural and functional integrity of SCSRs, such as the 'ECO OWL' once this concept is proven to be viable, should be supported by Government and Industry as a matter of priority. It should be borne in mind that the ultimate objective is to reduce risk.**

The above observations, in some form or another, have been raised in previous reports. As an initial step it is proposed that consideration be given to holding of Industry and DMR Inspectorate workshops and to follow-up on those events held in 2013 and 2015, or even to integrate such workshops as part of an established mine health and safety conference.

The general objective would be to develop a realistic strategy and to translate this into a plan of action.

4.2 SCSR performance

Despite the large number of SCSR deployed in the mining industry, the MSA/SavOx units tested in 2015 suggest a sharp decline in deployment of this particular unit. The MSA/SavOx SCSR represents now only 2% of the units used in the SA mining industry. The TTC considers the continued use of the MSA/SavOx manufactured prior to 2008 to constitute a significant risk with approximately 28 % of units performing satisfactorily. The affected mines have been notified about the reduction in the safe functional duration of the SCSR manufactured prior 2008. Under emergency escape conditions a premature increase in breathing resistance is a physiological limitation that extends beyond any psychological barrier and the inability to continue cannot simply be dismissed because of a perceived lack of motivation on the part of the escapee.

Although the majority of the tested units did perform below the rated duration, only one unit was rejected as per category 2 of SCSR monitoring criteria (safe functional duration of less than 15 minutes).

The Draeger Oxyboks K35 units performed satisfactory with 99,21% performing above their rated duration. This consistency in functional performance will be a benchmark for the new Draeger Oxyboks K35A model, which passed compliance testing in accordance with SANS 1737:2008 and was introduced into the SA mining industry in 2014.

As pointed out in section 3.2, the remaining SCSR types that contributed to the failure rate in 2015 were the AfroxPac35 and AfroxPac35i SCSRs. It is concerning that of the total failure rate observed in these two types of units (0,23%), the AfroxPac35 contributed a greater percentage of 0,18%..

In general, a consistent functional performance was observed from the Roxy40 SCSRs during this reporting period. A major reduction of casing leakages from 19,3% in 2014 to 0% in 2015 has obvious added value to this consistency in functional performance. This improvement follows from the interaction between the TTC and the OEM based on the findings of the monitoring programme.

The generalreduction in protective casing leakage could well be attributed to more regular service contracts entered into between the OEM / supplier and the mines.

4.3 Mine infrastructures

The large number of SCSRs deployed in the South African mining industry (Table 2) has several implications. The increase in the number recorded in the platinum sector are due to the realization that the introduction of SCSRs were deemed increasingly to provide adequate mitigation to the risk posed during fires and in the aftermath of explosion or occurrence of noxious gases in underground mines and effect self-escape of workers to places of safety.

The number of mines entering into formal and comprehensive maintenance contracts with manufacturers or suppliers exhibits a further increase on a year to year basis. To a large extent this provides a substantial counter to the challenges imposed on mines' SCSR maintenance infrastructures.

The increase of leak testing of SCSRs' protective casings by the mines over and above the requirements of maintenance/service contracts is, once again, one of the most positive aspects to emerge from the current review. Although the accuracy of some leak testers used by mines requires independent confirmation, the most likely immediate benefit is in the knowledge that the units would be likely to perform as intended when activated and used.

4.4 Compliance with legislation

Overall compliance with legislation, on the basis of a summation of Compliance levels 1 and 2 (see Table 6), still appears to be satisfactory. However, this report indicates clearly that Compliance level 1 exhibit a disconcerting downward trend. The fundamental issue may well be the inability of mines' infrastructures to cope with the large number of SCSRs while making it impossible to maintain the higher standards associated with Compliance level 1.

It is notable that the ATA compliance level rating criteria is under severe criticism, thus, the TTC is reviewing the criteria with the aim of standardizing it. The reviewed criteria will be an annex to the lamproom Code of Practice.

A crucial observation is that 23 mines could only achieve a Compliance level 3 rating. This represents a significant number of employees being subjected, potentially at least, to an unacceptable degree of risk regarding their SCSRs not functioning as intended in an emergency thereby putting the lives of the affected workers in danger. . This situation is of concern and should be addressed by the affected mines (who by the way should be notified by the DMR and should be subjected by close scrutiny by the Inspectorate as part of the system that the TTC has proposed).

Regulations 16.2(3), 16.3 and 16.4(2) are of fundamental importance because they enable a rating of 'compliance levels' for mines or operational units. Current findings are disconcerting and it is more than evident that the reasons for non-compliance be investigated as a priority. Statistically the number of mines or operational units that fall within 'Level 3 compliance' (i.e. insufficient standards; non-compliance) are increasing and it is of great concern that at this mines a high number of employees are possibly exposed to a significant risk of SCSR failure on a day-to-day basis.

4.5 Recommendations

A review of the Annual Report 1999 to 2015, calls for the development of a structured auditing protocol along the lines of a DMR Guideline, with input from the ATA, Industry, the DMR and OEMs/suppliers. This initiative is seen to be complementary to the current monitoring programme and should be therefore considered seriously.

SCSR monitoring, in terms of Regulation 16.4(1) of the MHS Act, is in its current format a well-established and a mature programme for the assessment of SCSR performance trends and incidents of malfunction and to provide some prediction of SCSR functional performance condition. The efficacy of the programme also depends substantially on mines' infrastructures, standards and information bases.

After nineteen years of formal industry-wide SCSR monitoring, it seems imperative to subject the entire monitoring programme to a critical review with the objective of introducing further refinements to meet current conditions and to prepare for future challenges, including the possible and long overdue introduction of long-duration SCSRs monitoring into this programme.

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The DMR through its Inspectorate must ensure during their audits and inspections at the mines that all units are covered by batch approval compliance certificates.

Mine management should examine the competency of lamproom personnel in order to identify any shortcomings to ensure Compliance level 1.

Regulation 16 provides some guidance to mines in respect of SCSR support systems. These stipulations should be re-examined with the objective of introducing a formal and more detailed 'best practice' industry guidance note, which would, as a matter of course, further enhance the value of the current SCSR monitoring programme.

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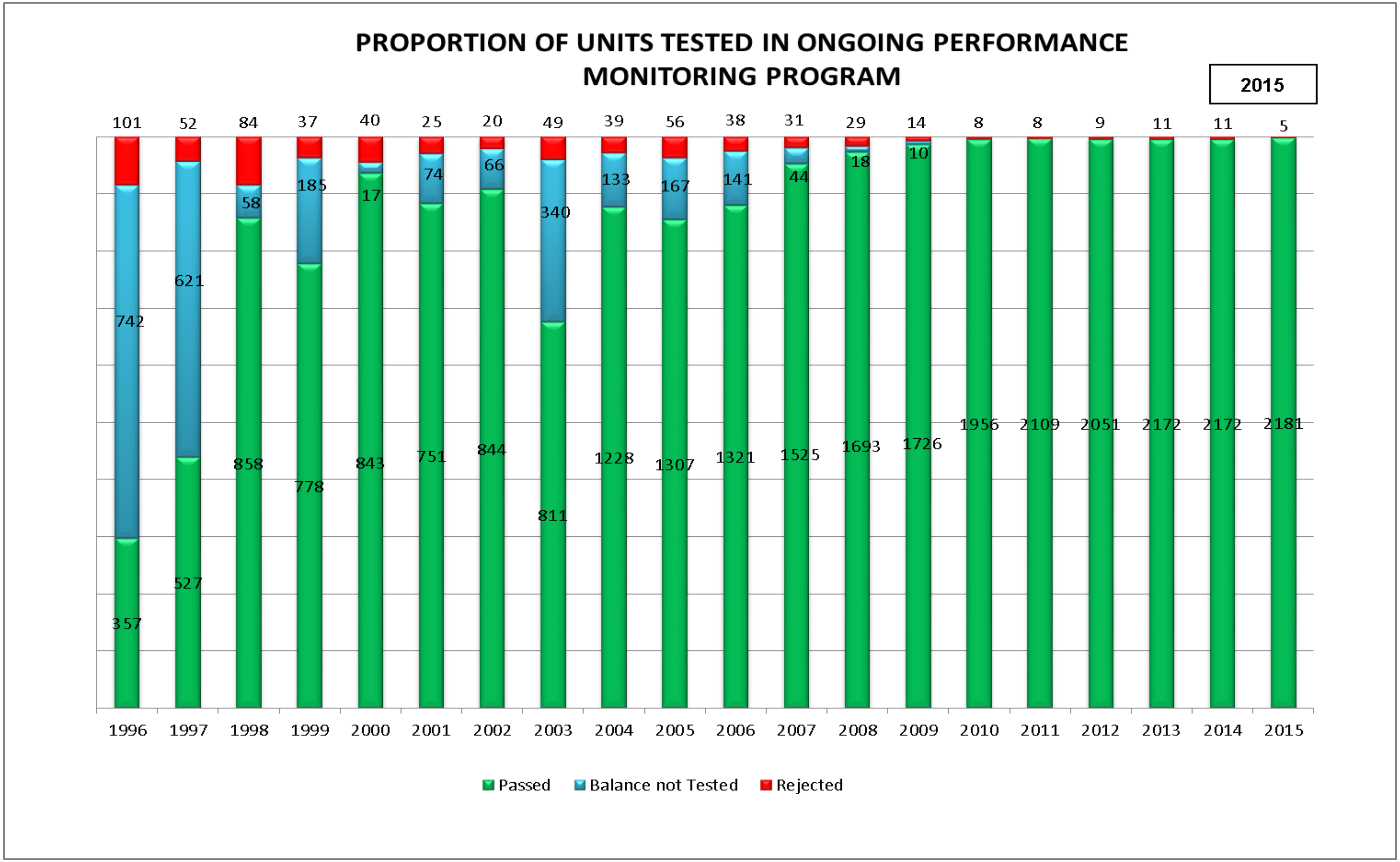
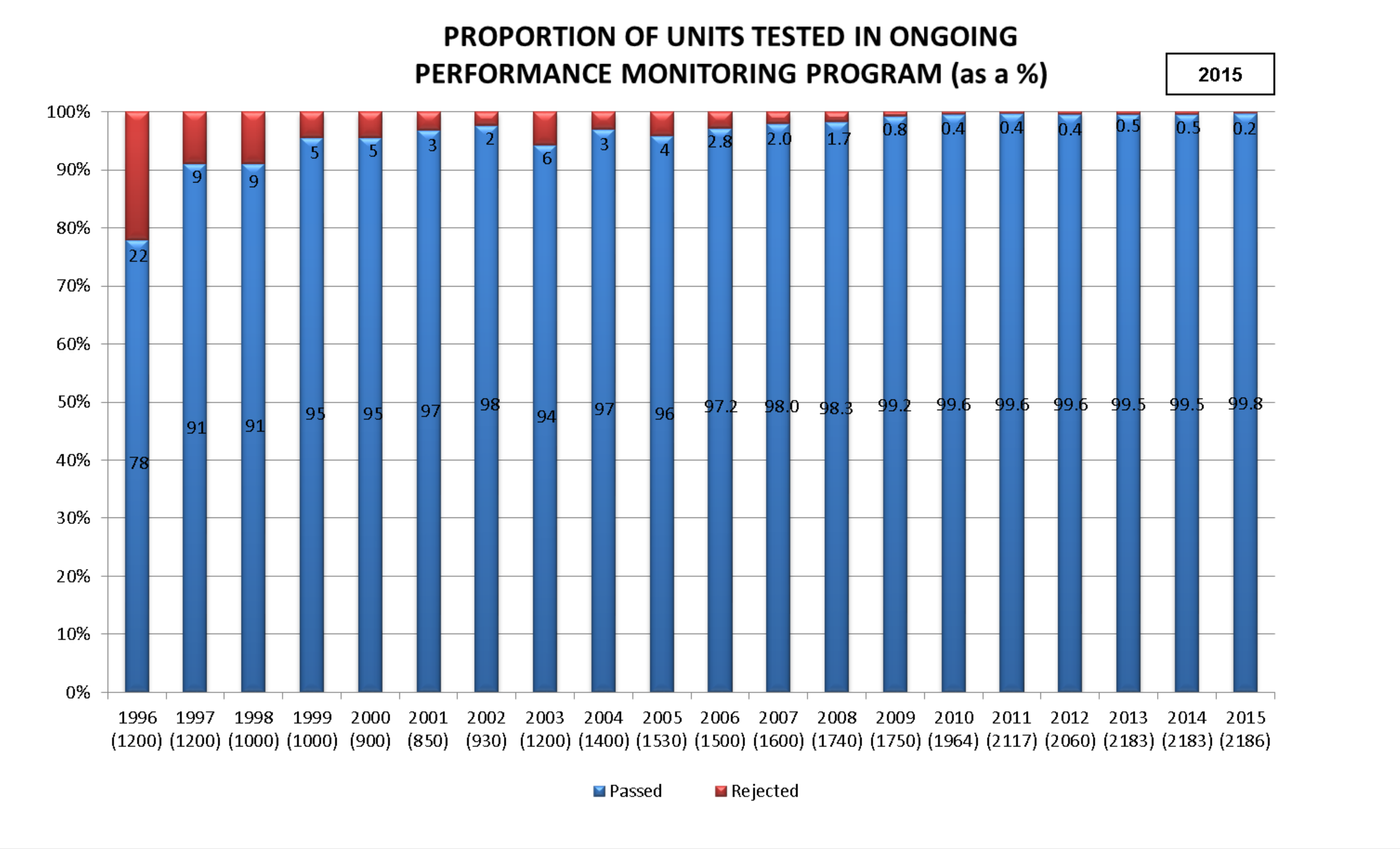
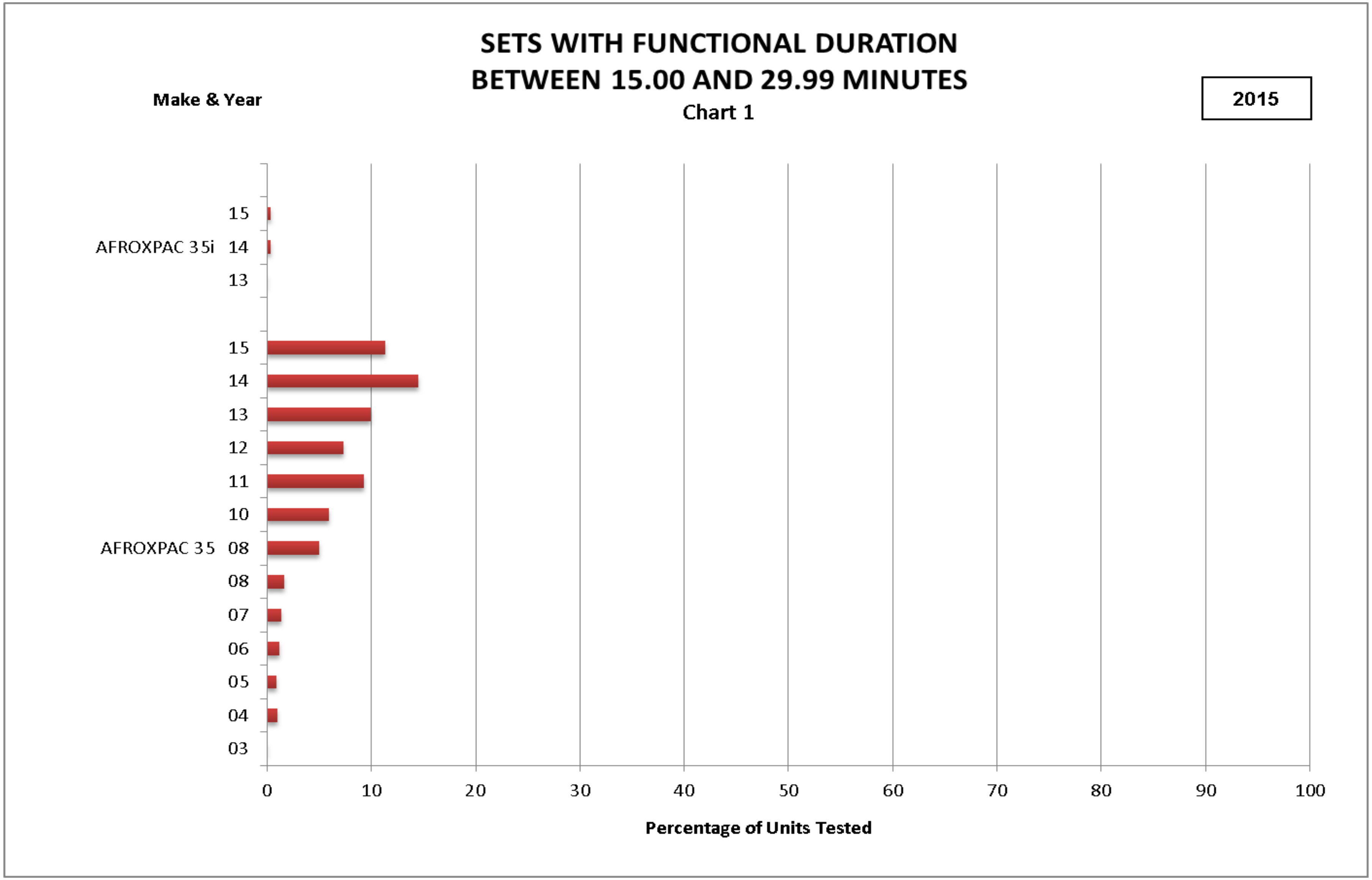
Appendix 1

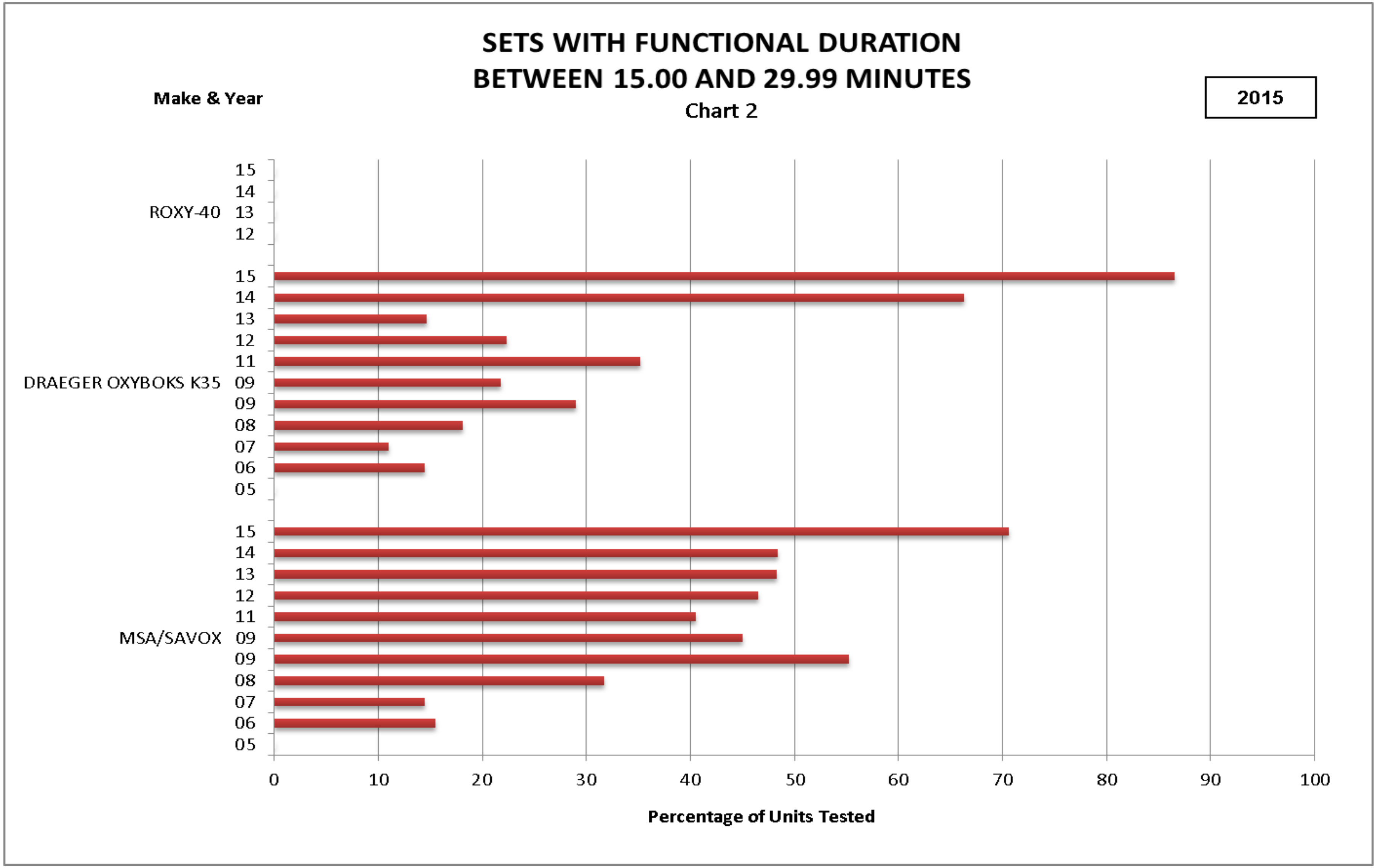
Performance graphs for SCSRs since 2002

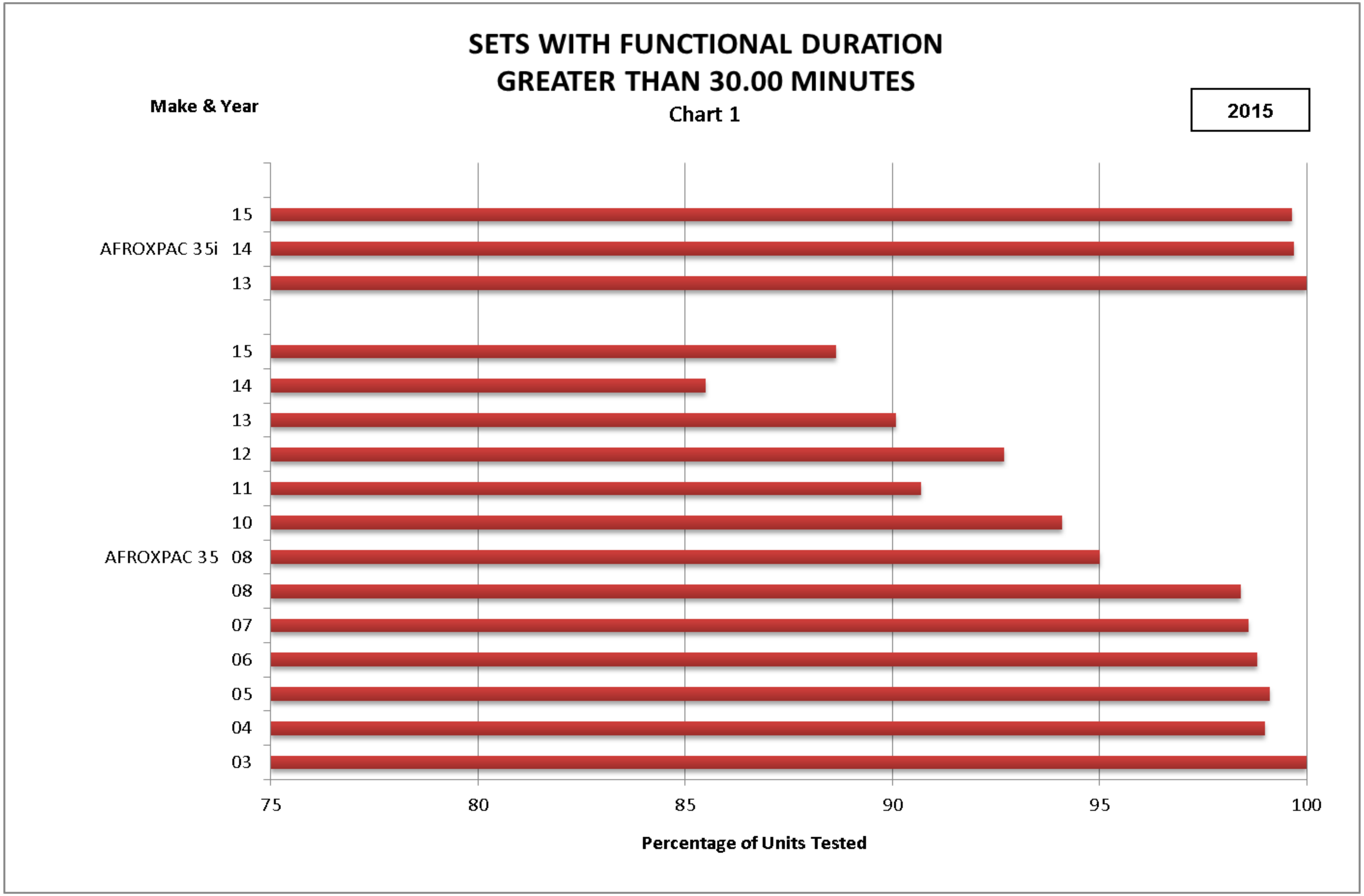


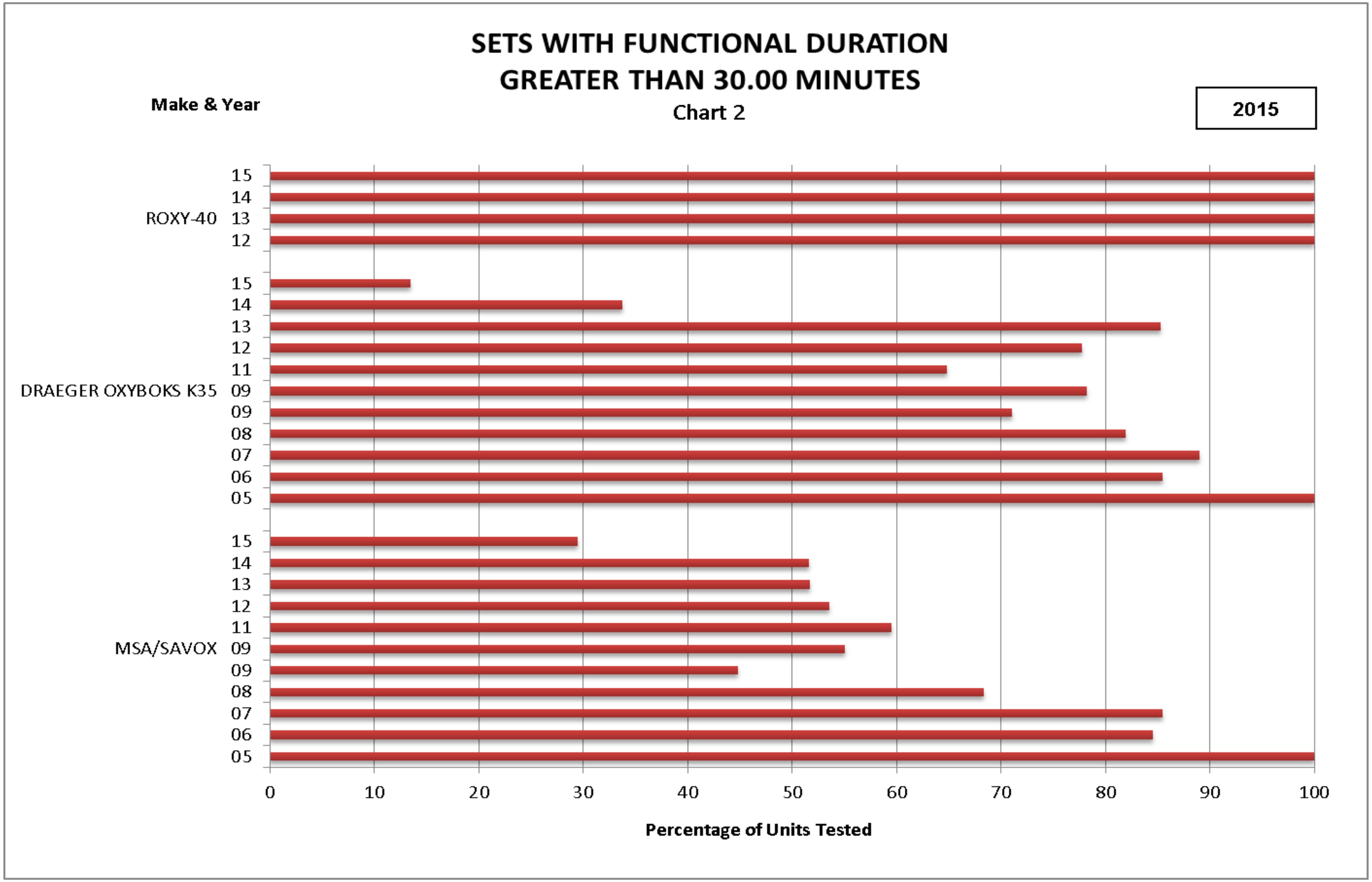
PROPORTION OF UNITS TESTED IN ONGOING PERFORMANCE MONITORING PROGRAM
2015
101
52
84
37
40
25
20
49
39
56
38
31
29
14
8
8
9
11
11
5
742
621
58
185
17
74
66
340
133
167
141
44
18
10
357
527
858
778
843
751
844
811
1228
1307
1321
1525
1693
1726
1956
2109
2051
2172
2172
2181
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Passed
Balance not Tested
Rejected

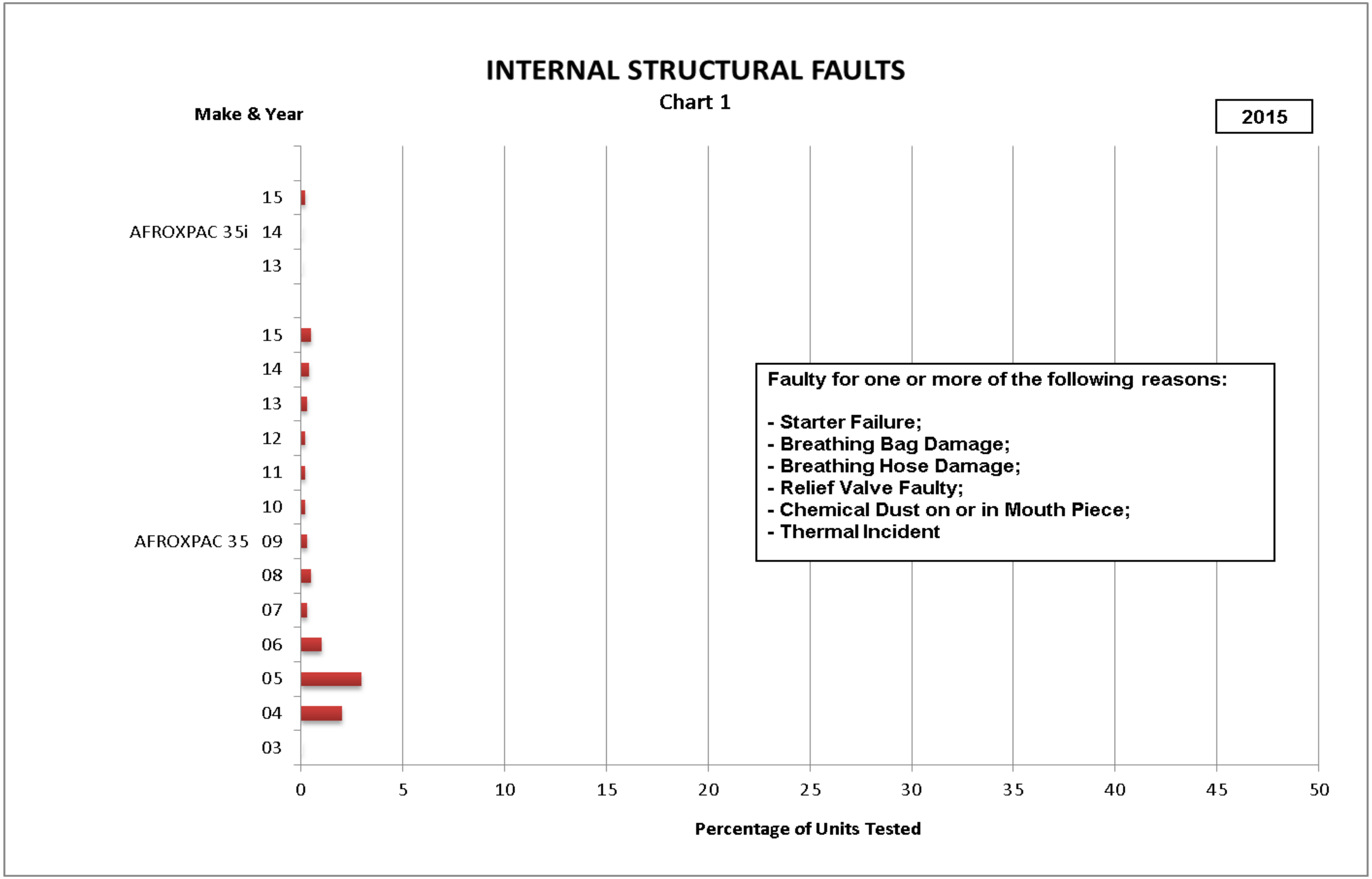

PROPORTION OF UNITS TESTED IN ONGOING PERFORMANCE MONITORING PROGRAM (as a %)
2015
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
22
78
9
91
9
91
5
95
5
95
3
97
2
98
6
94
3
97
4
96
2.8
97.2
2.0
98.0
1.7
98.3
0.8
99.2
0.4
99.6
0.4
99.6
0.4
99.6
0.5
99.5
0.5
99.5
0.2
99.8
1996 (1200)
1997 (1200)
1998 (1000)
1999 (1000)
2000 (900)
2001 (850)
2002 (930)
2003 (1200)
2004 (1400)
2005 (1530)
2006 (1500)
2007 (1600)
2008 (1740)
2009 (1750)
2010 (1964)
2011 (2117)
2012 (2060)
2013 (2183)
2014 (2183)
2015 (2186)
Passed
Rejected

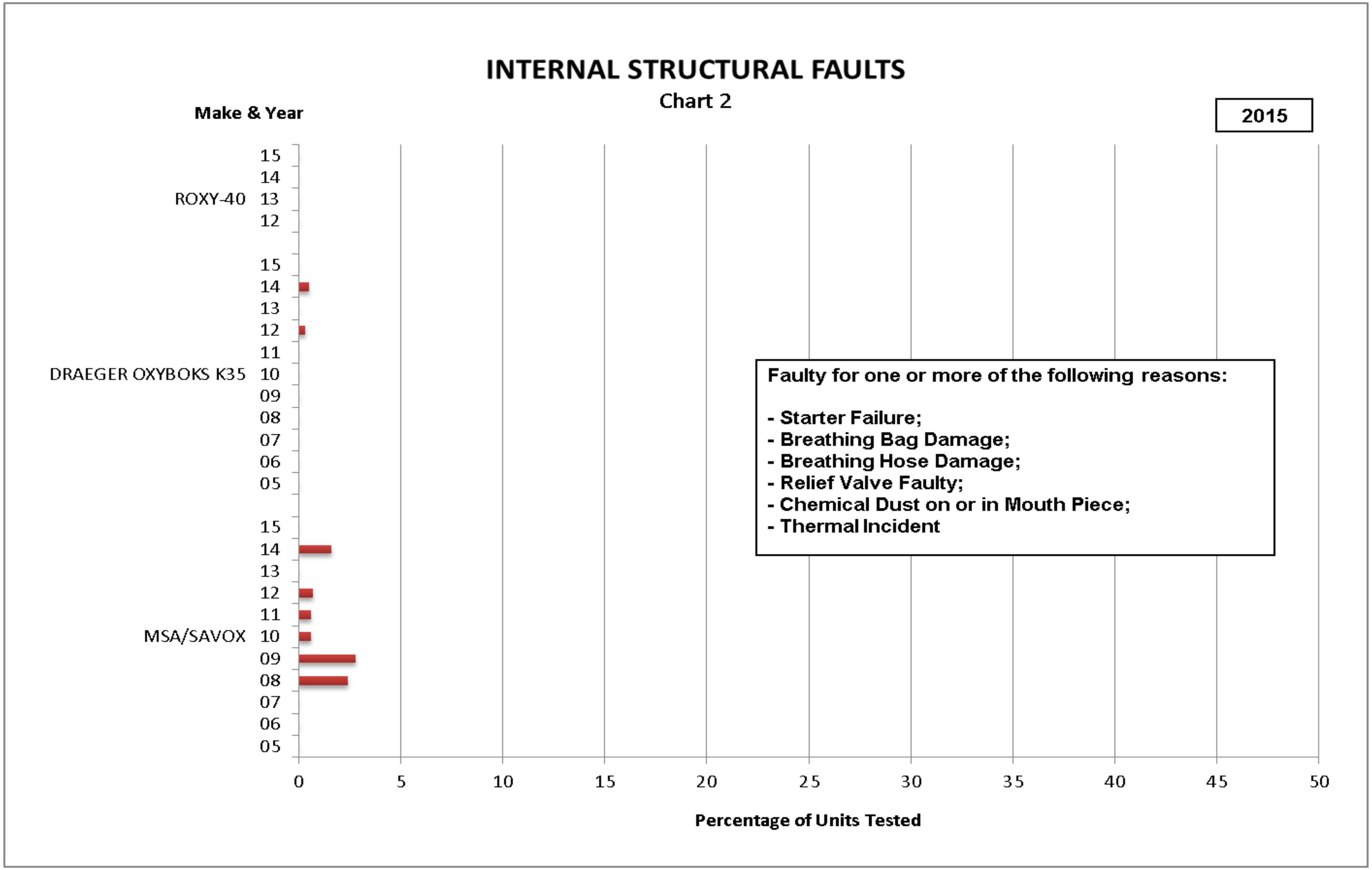

SETS WITH FUNCTIONAL DURATION
BETWEEN 15.00 AND 29.99 MINUTES
Chart 1
Make & Year
2015
15
AFROXPAC 35i 14
13
15
14
13
12
11
10
AFROXPAC 35 08
08
07
06
05
04
03
0
10
20
30
40
50
60
70
80
90
100
Percentage of Units Tested

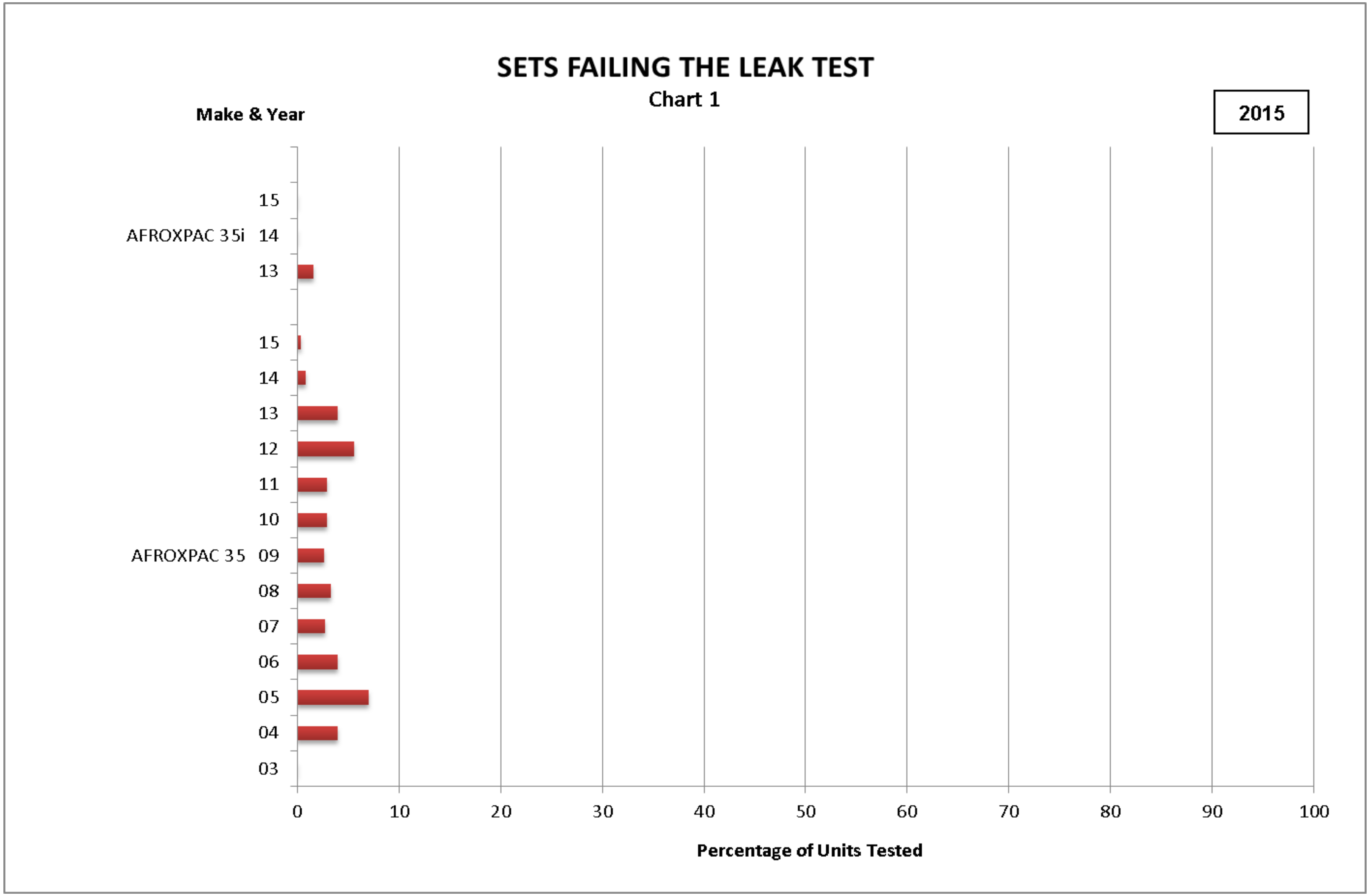

SETS WITH FUNCTIONAL DURATION
BETWEEN 15.00 AND 29.99 MINUTES
Chart 2
Make & Year
2015
ROXY-40
15
14
13
12
DRAEGER OXYBOKS K35
15
14
13
12
11
09
09
08
07
06
05
MSA/SAVOX
15
14
13
12
11
09
09
08
07
06
05
0
10
20
30
40
50
60
70
80
90
100
Percentage of Units Tested

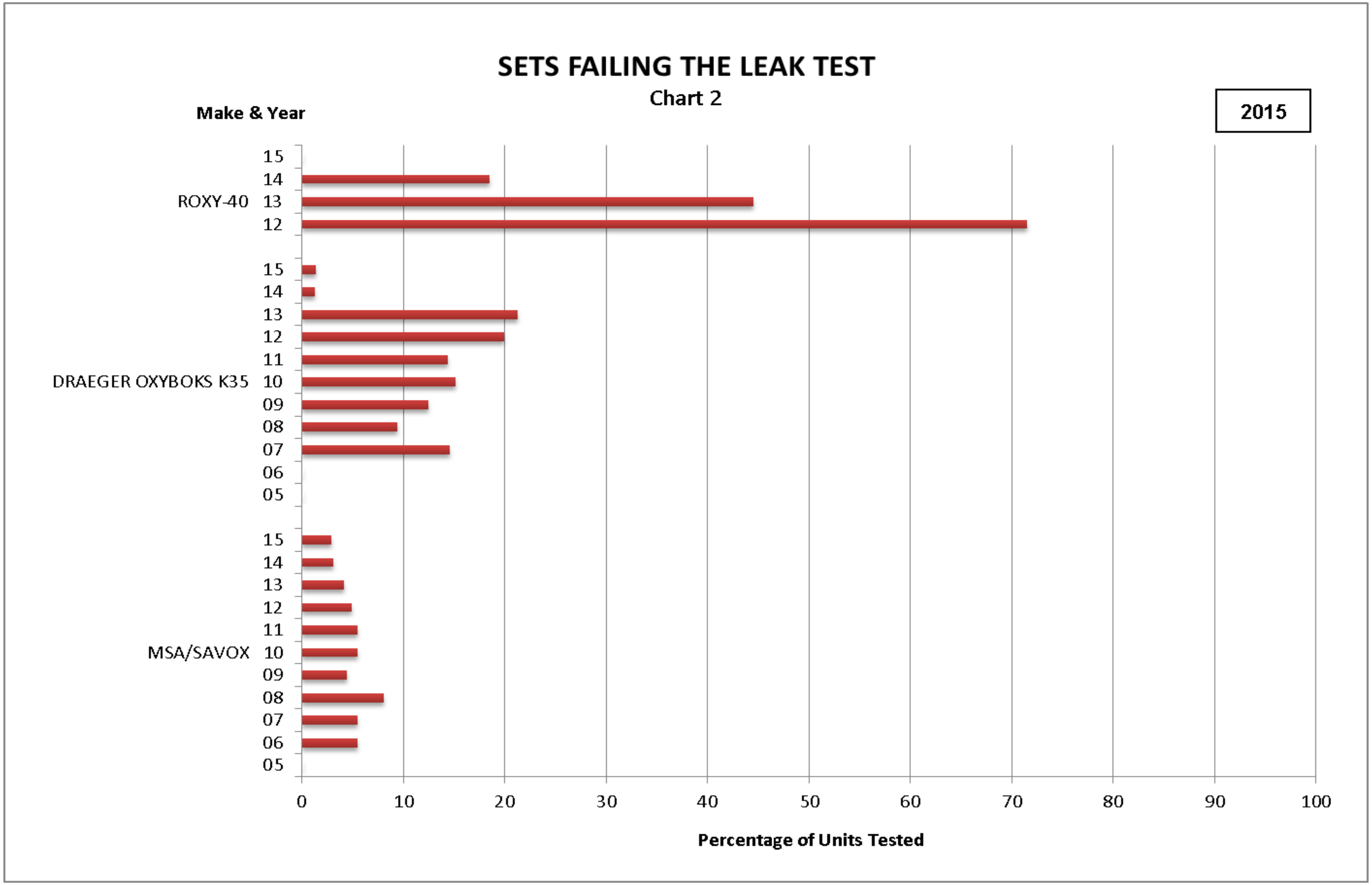

SETS WITH FUNCTIONAL DURATION
GREATER THAN 30.00 MINUTES
Chart 1
Make & Year
2015
AFROXPAC 35i
15
14
13
AFROXPAC 35
15
14
13
12
11
10
08
08
07
06
05
04
03
75
80
85
90
95
100
Percentage of Units Tested

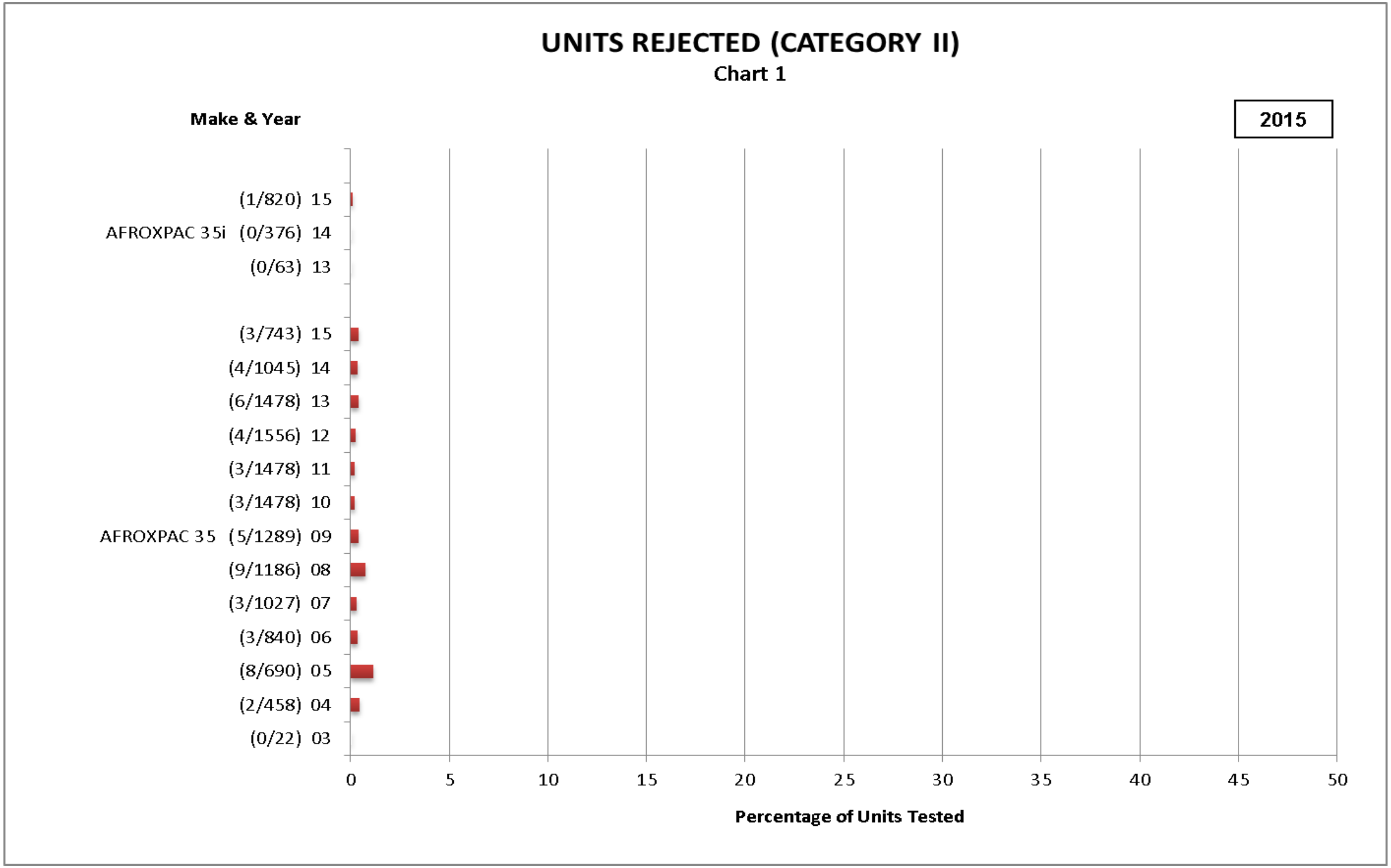

SETS WITH FUNCTIONAL DURATION
GREATER THAN 30.00 MINUTES
Chart 2
Make & Year
2015
ROXY-40
15
14
13
12
DRAEGER OXYBOKS K35
15
14
13
12
11
09
09
08
07
06
05
MSA/SAVOX
15
14
13
12
11
09
09
08
07
06
05
0
10
20
30
40
50
60
70
80
90
100
Percentage of Units Tested

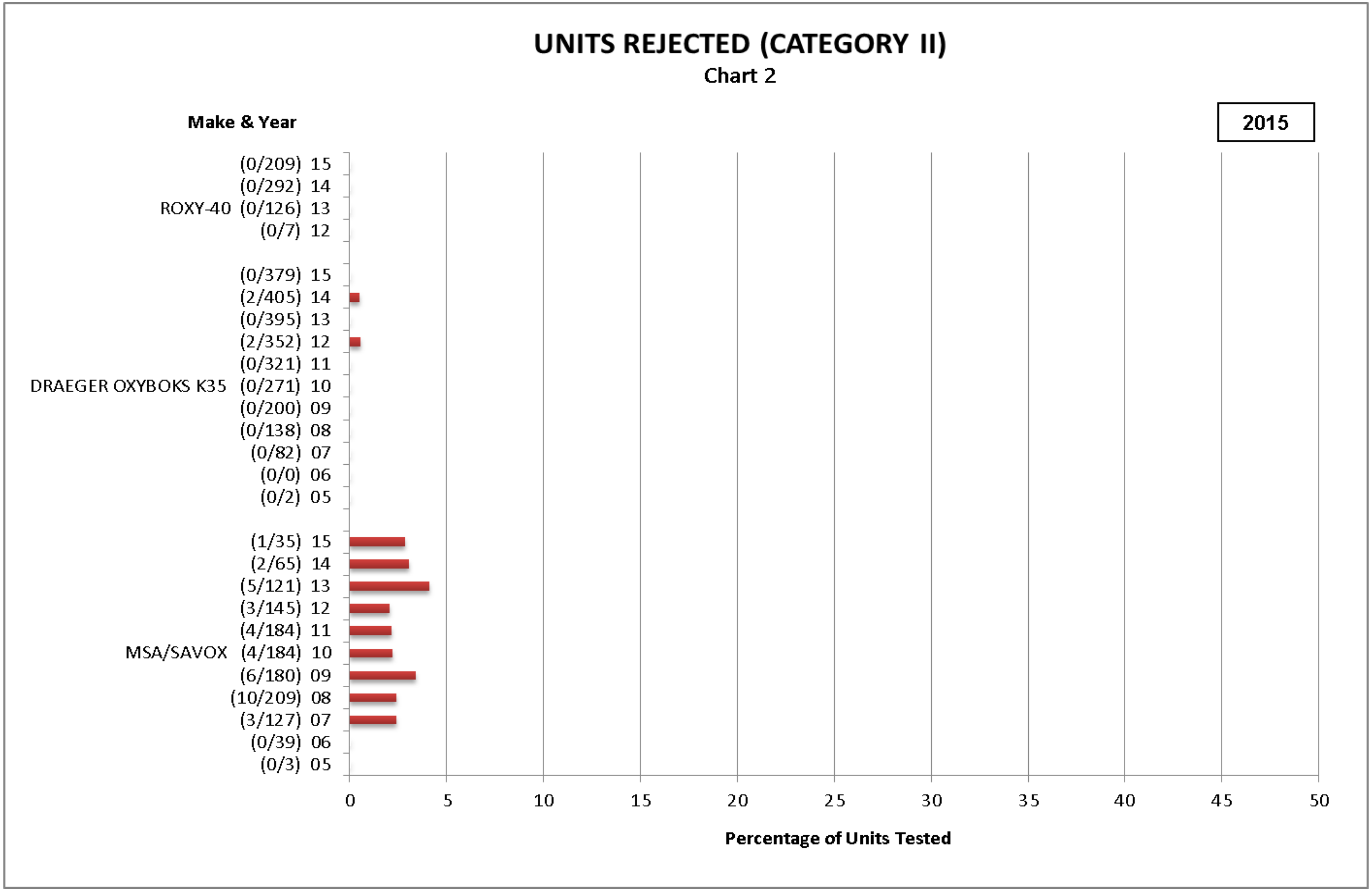

INTERNAL STRUCTURAL FAULTS
Chart 1
Make & Year
2015
AFROXPAC 35i
15
14
13
AFROXPAC 35
15
14
13
12
11
10
09
08
07
06
05
04
03
0
5
10
15
20
25
30
35
40
45
50
Percentage of Units Tested
Faulty for one or more of the following reasons:
- Starter Failure;
- Breathing Bag Damage;
- Breathing Hose Damage;
- Relief Valve Faulty;
- Chemical Dust on or in Mouth Piece;
- Thermal Incident

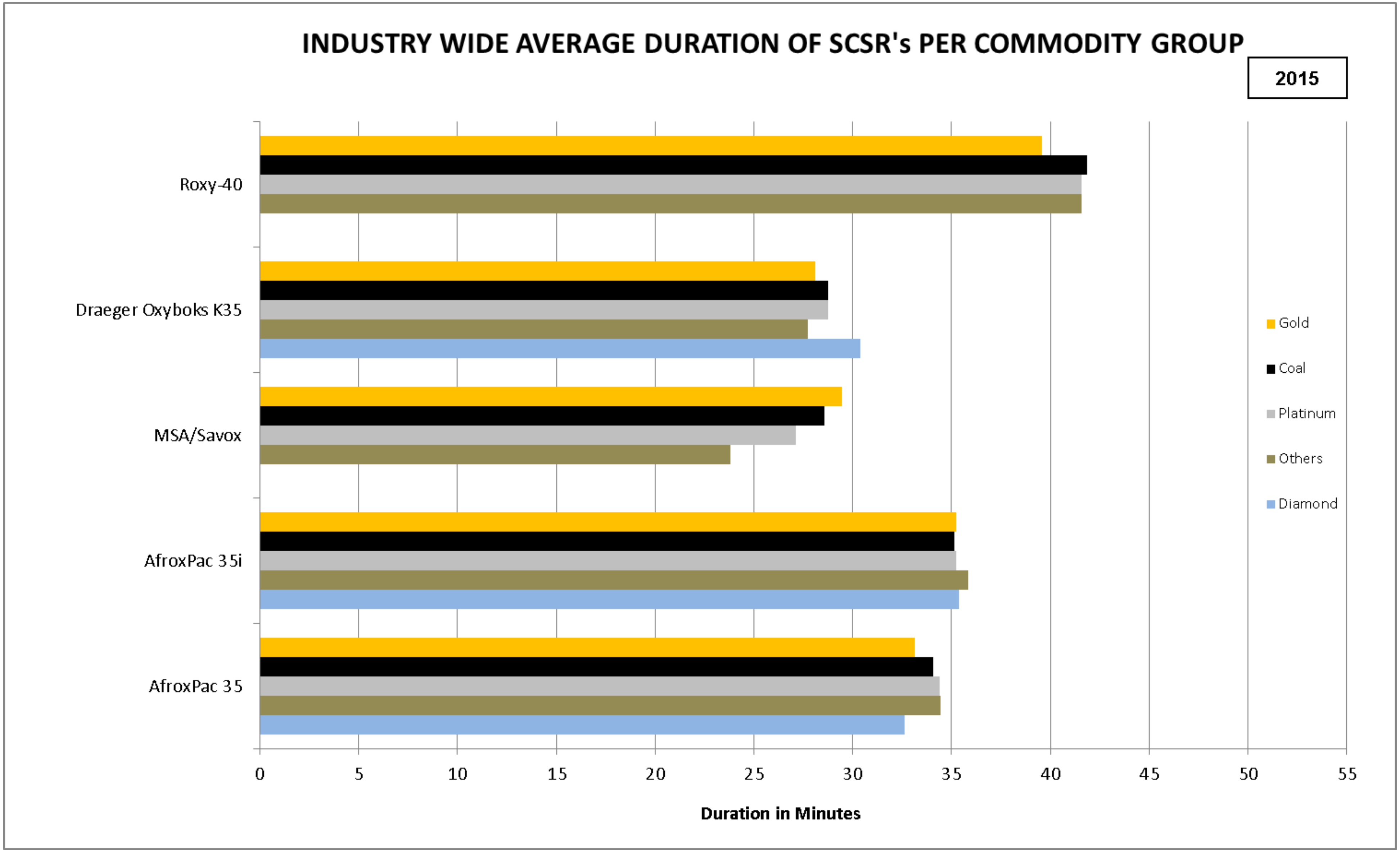

INTERNAL STRUCTURAL FAULTS
Chart 2
Make & Year
2015
ROXY-40
15
14
13
12
DRAEGER OXYBOKS K35
15
14
13
12
11
10
09
08
07
06
05
MSA/SAVOX
15
14
13
12
11
10
09
08
07
06
05
0
5
10
15
20
25
30
35
40
45
50
Percentage of Units Tested
Faulty for one or more of the following reasons:
- Starter Failure;
- Breathing Bag Damage;
- Breathing Hose Damage;
- Relief Valve Faulty;
- Chemical Dust on or in Mouth Piece;
- Thermal Incident

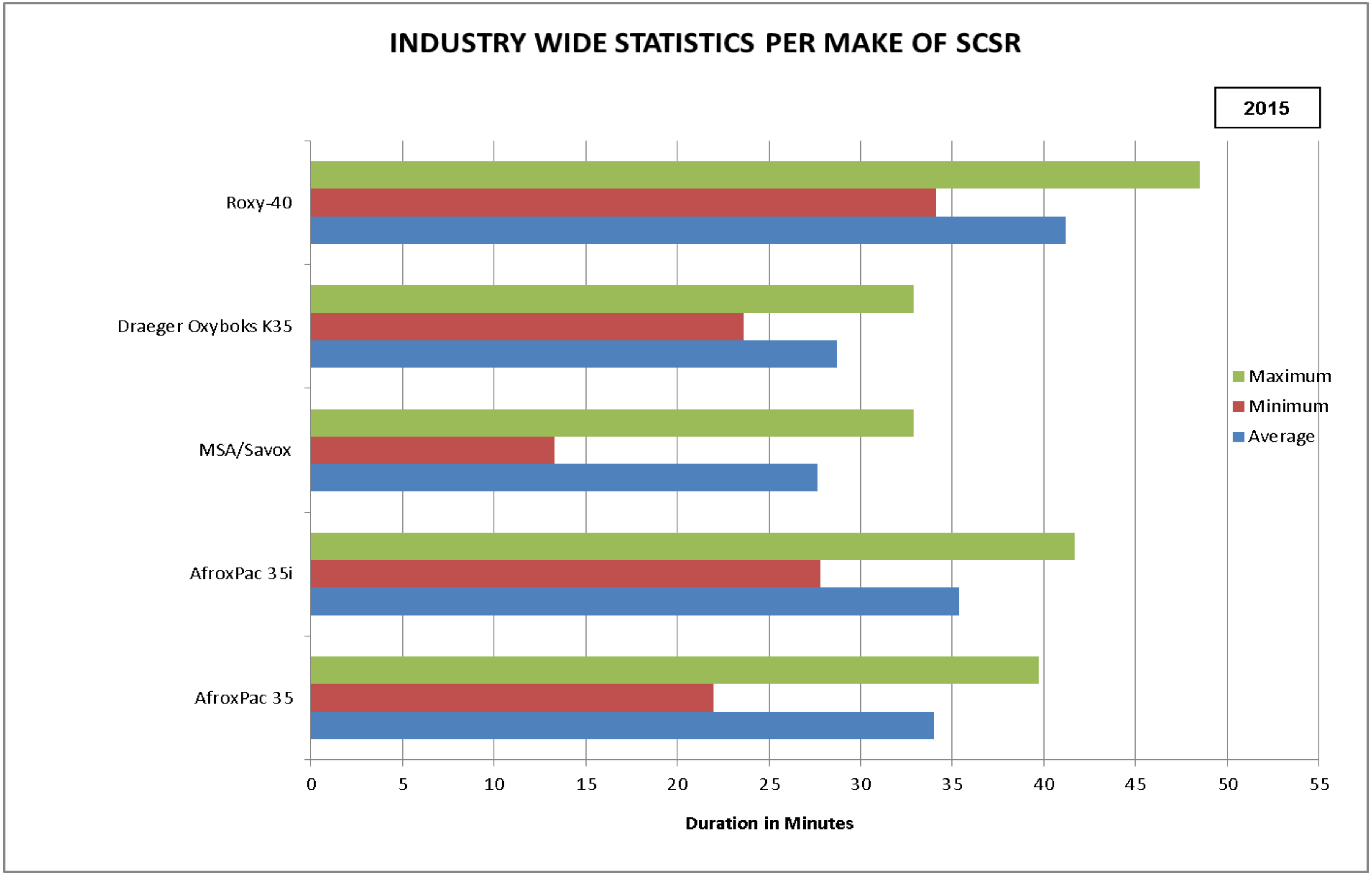

SETS FAILING THE LEAK TEST
Chart 1
Make & Year
2015
AFROXPAC 35i
15
14
13
AFROXPAC 35
15
14
13
12
11
10
09
08
07
06
05
04
03
0
10
20
30
40
50
60
70
80
90
100
Percentage of Units Tested

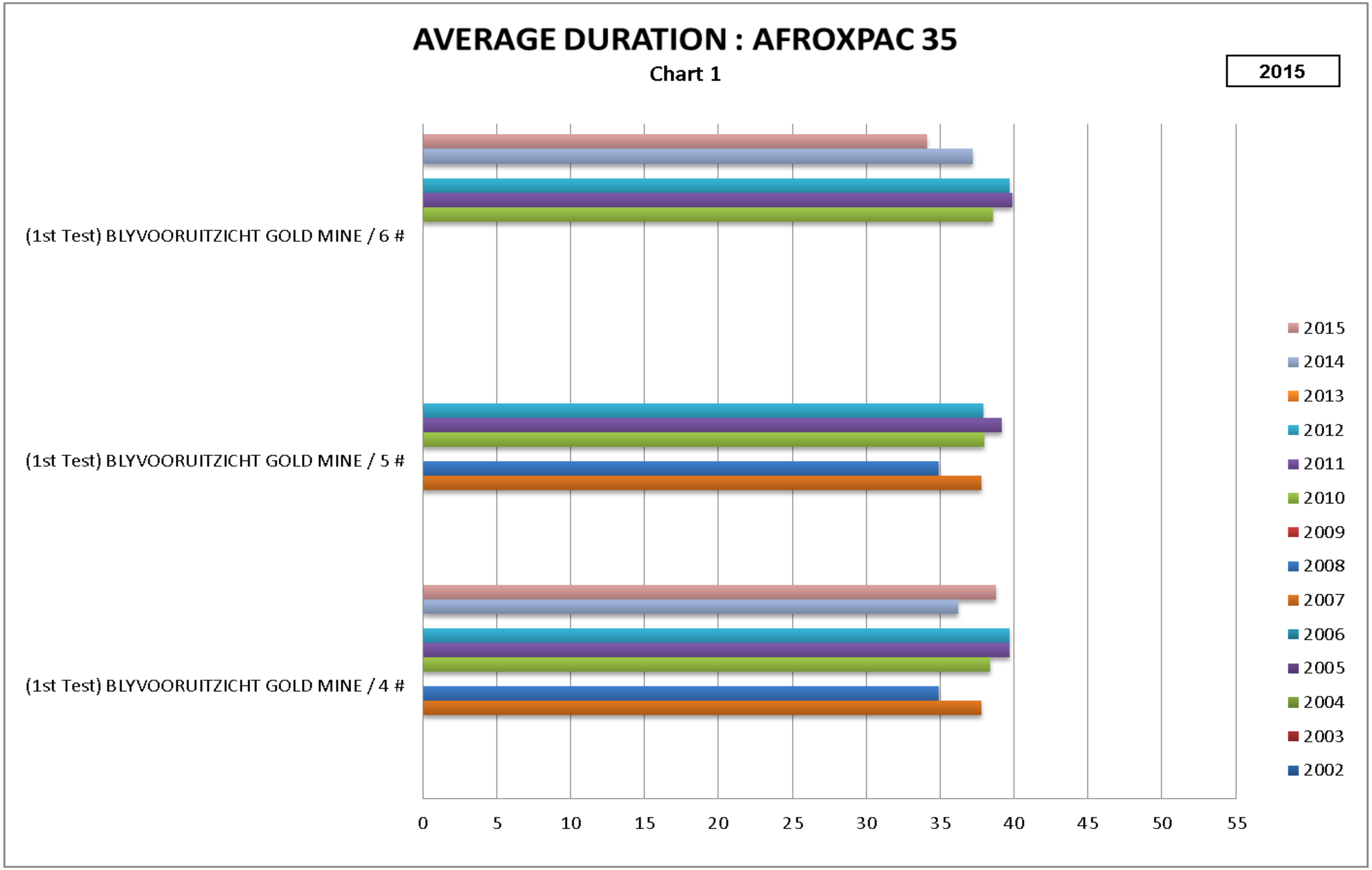

SETS FAILING THE LEAK TEST
Chart 2
Make & Year
2015
ROXY-40
DRAEGER OXYBOKS K35
MSA/SAVOX
15
14
13
12
11
10
09
08
07
06
05
0
10
20
30
40
50
60
70
80
90
100
Percentage of Units Tested

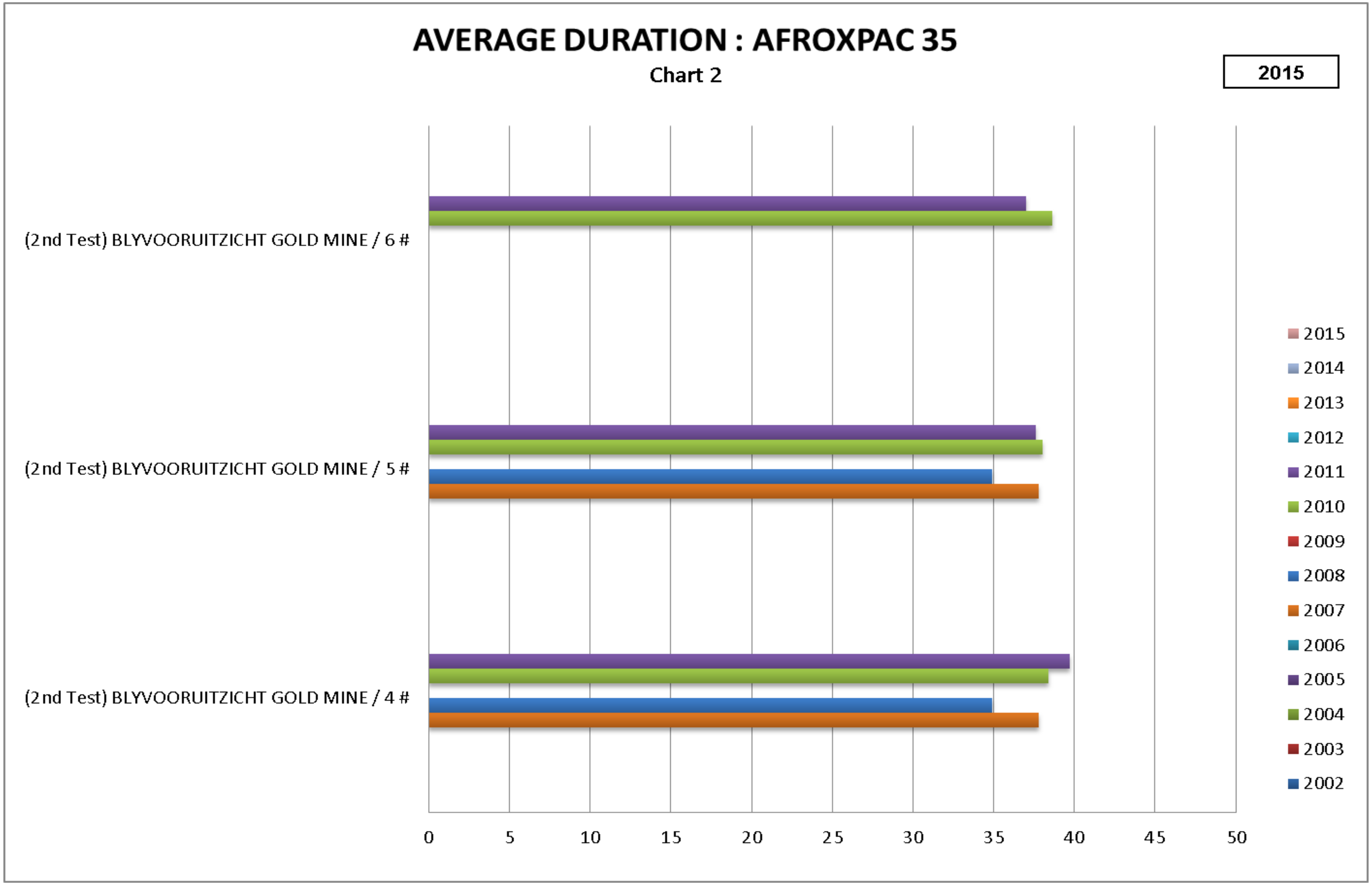

UNITS REJECTED (CATEGORY II)
Chart 1
Make & Year
2015
(1/820) 15
AFROXPAC 35i (0/376) 14
(0/63) 13
(3/743) 15
(4/1045) 14
(6/1478) 13
(4/1556) 12
(3/1478) 11
(3/1478) 10
AFROXPAC 35 (5/1289) 09
(9/1186) 08
(3/1027) 07
(3/840) 06
(8/690) 05
(2/458) 04
(0/22) 03
0
5
10
15
20
25
30
35
40
45
50
Percentage of Units Tested

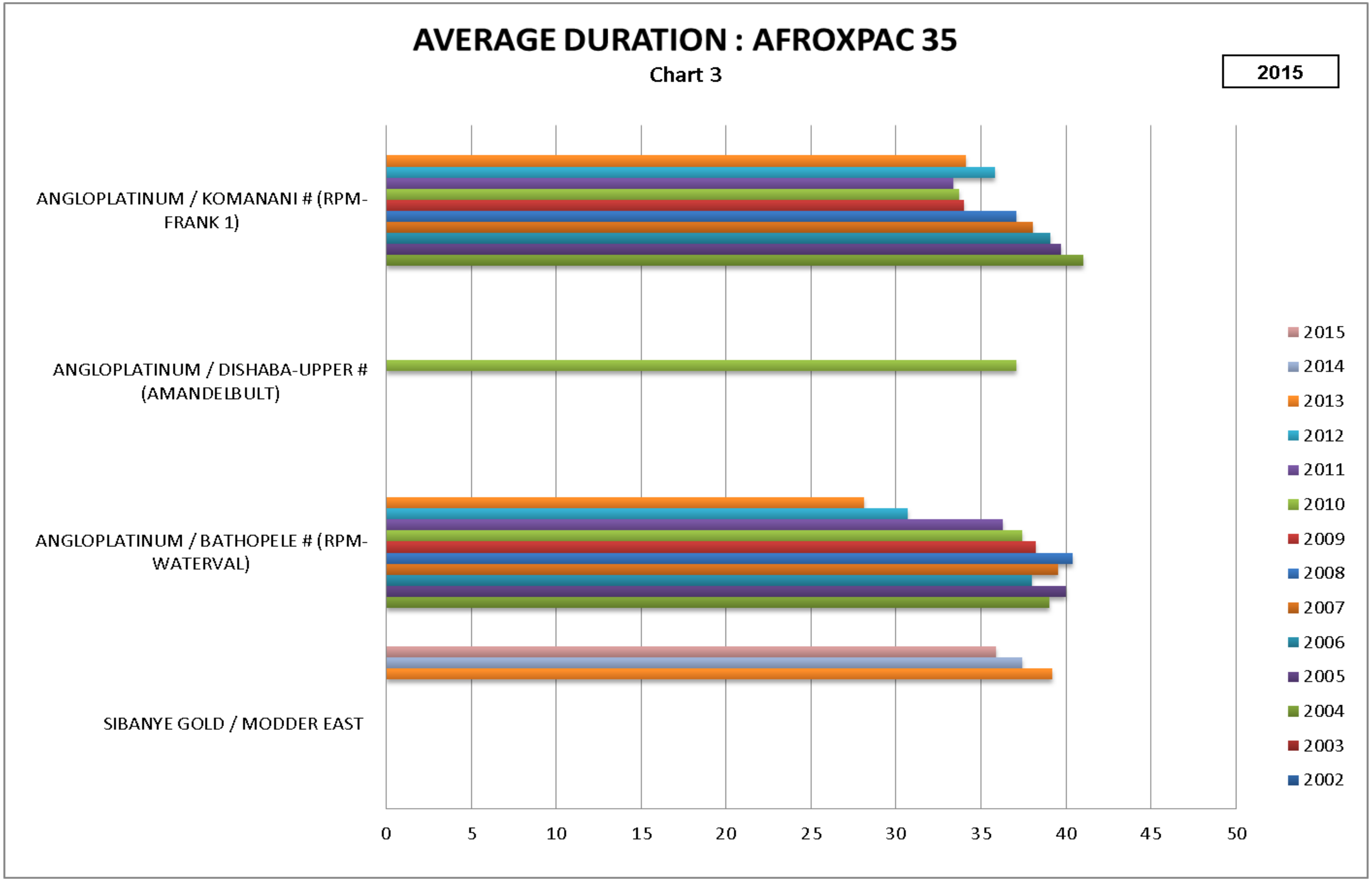

UNITS REJECTED (CATEGORY II)
Chart 2
Make & Year
2015
(0/209) 15
(0/292) 14
ROXY-40 (0/126) 13
(0/7) 12
(0/379) 15
(2/405) 14
(0/395) 13
(2/352) 12
(0/321) 11
DRAEGER OXYBOKS K35 (0/271) 10
(0/200) 09
(0/138) 08
(0/82) 07
(0/0) 06
(0/2) 05
(1/35) 15
(2/65) 14
(5/121) 13
(3/145) 12
(4/184) 11
MSA/SAVOX (4/184) 10
(6/180) 09
(10/209) 08
(3/127) 07
(0/39) 06
(0/3) 05
0
5
10
15
20
25
30
35
40
45
50
Percentage of Units Tested

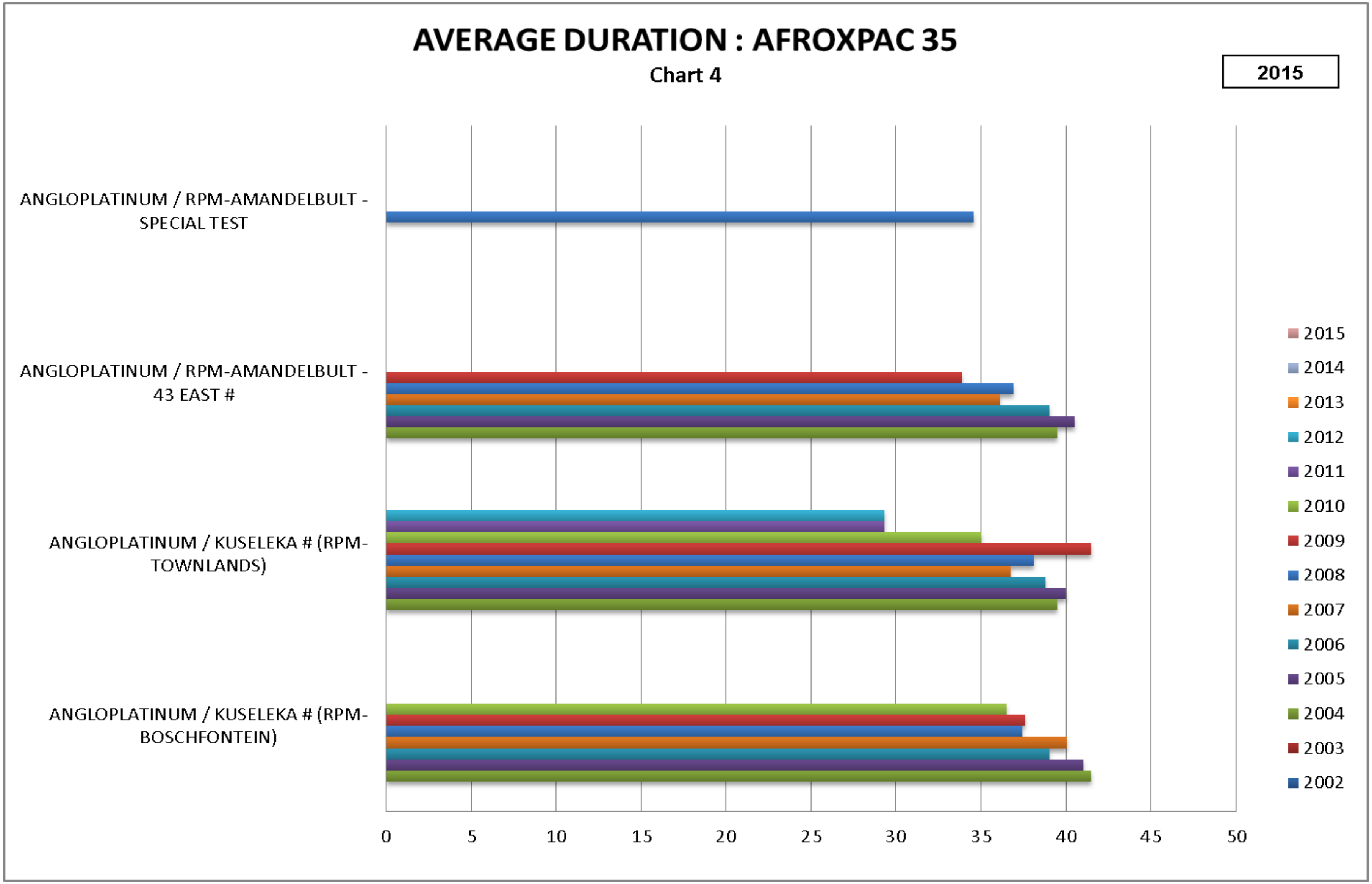

INDUSTRY WIDE AVERAGE DURATION OF SCSR's PER COMMODITY GROUP
2015
Roxy-40
Draeger Oxyboks K35
MSA/Savox
AfroxPac 35i
AfroxPac 35
0
5
10
15
20
25
30
35
40
45
50
55
Duration in Minutes
Gold
Coal
Platinum
Others
Diamond

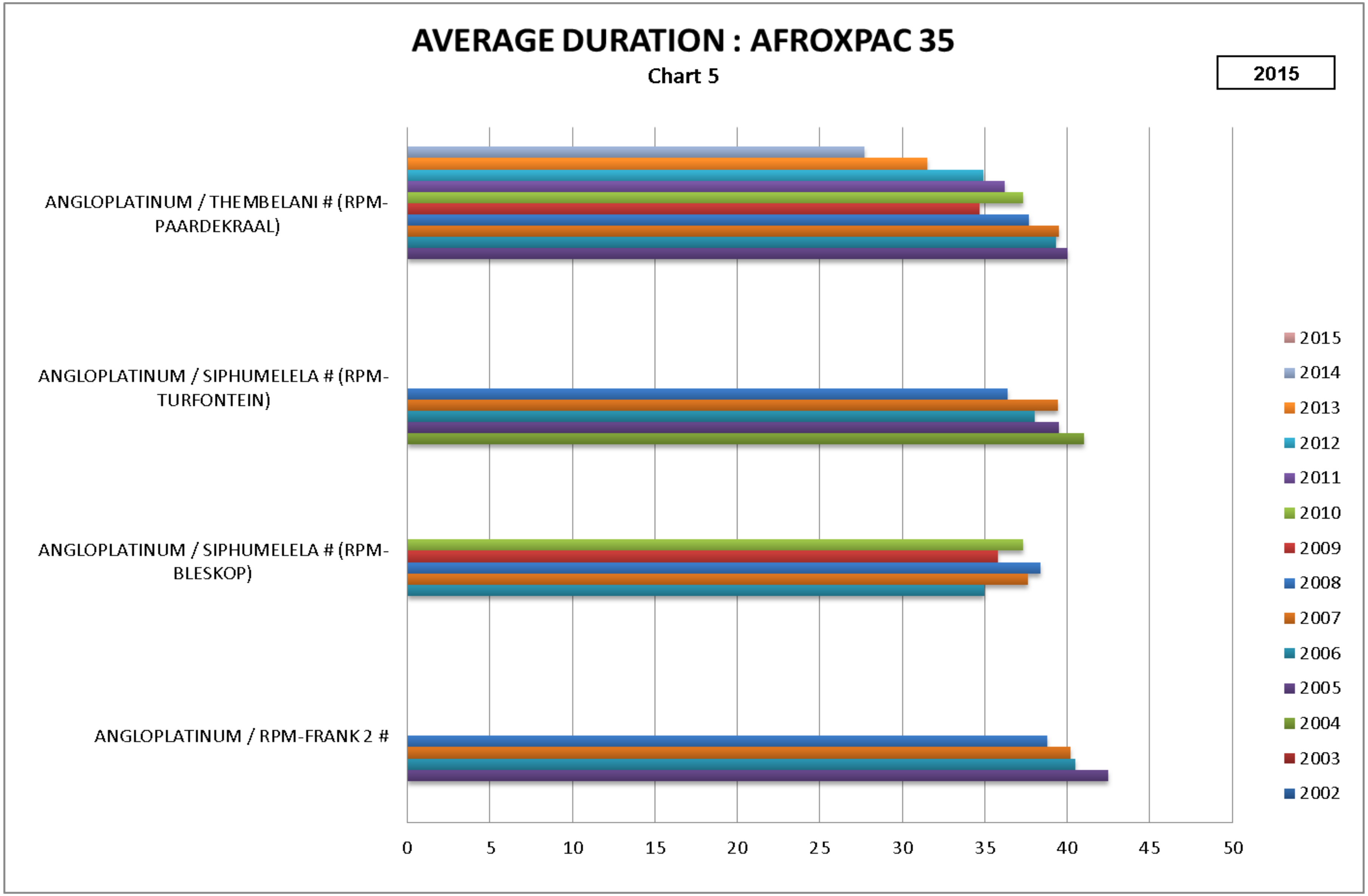

INDUSTRY WIDE STATISTICS PER MAKE OF SCSR
2015
Roxy-40
Draeger Oxyboks K35
MSA/Savox
AfroxPac 35i
AfroxPac 35
0
5
10
15
20
25
30
35
40
45
50
55
Duration in Minutes
Maximum
Minimum
Average

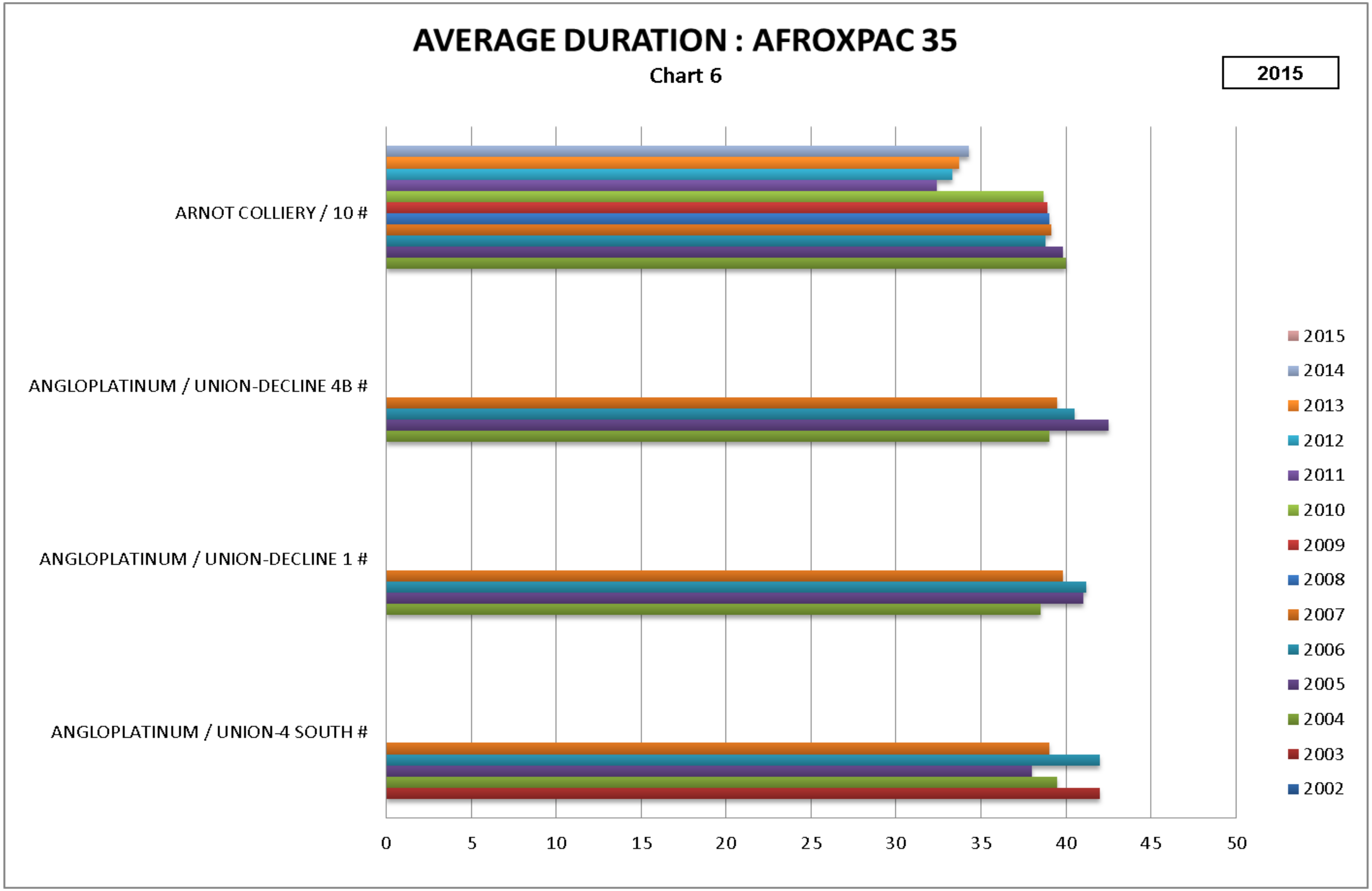

AVERAGE DURATION : AFROXPAC 35
Chart 1
2015
(1st Test) BLYVOORUITZICHT GOLD MINE / 6 #
(1st Test) BLYVOORUITZICHT GOLD MINE / 5 #
(1st Test) BLYVOORUITZICHT GOLD MINE / 4 #
0
5
10
15
20
25
30
35
40
45
50
55
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002

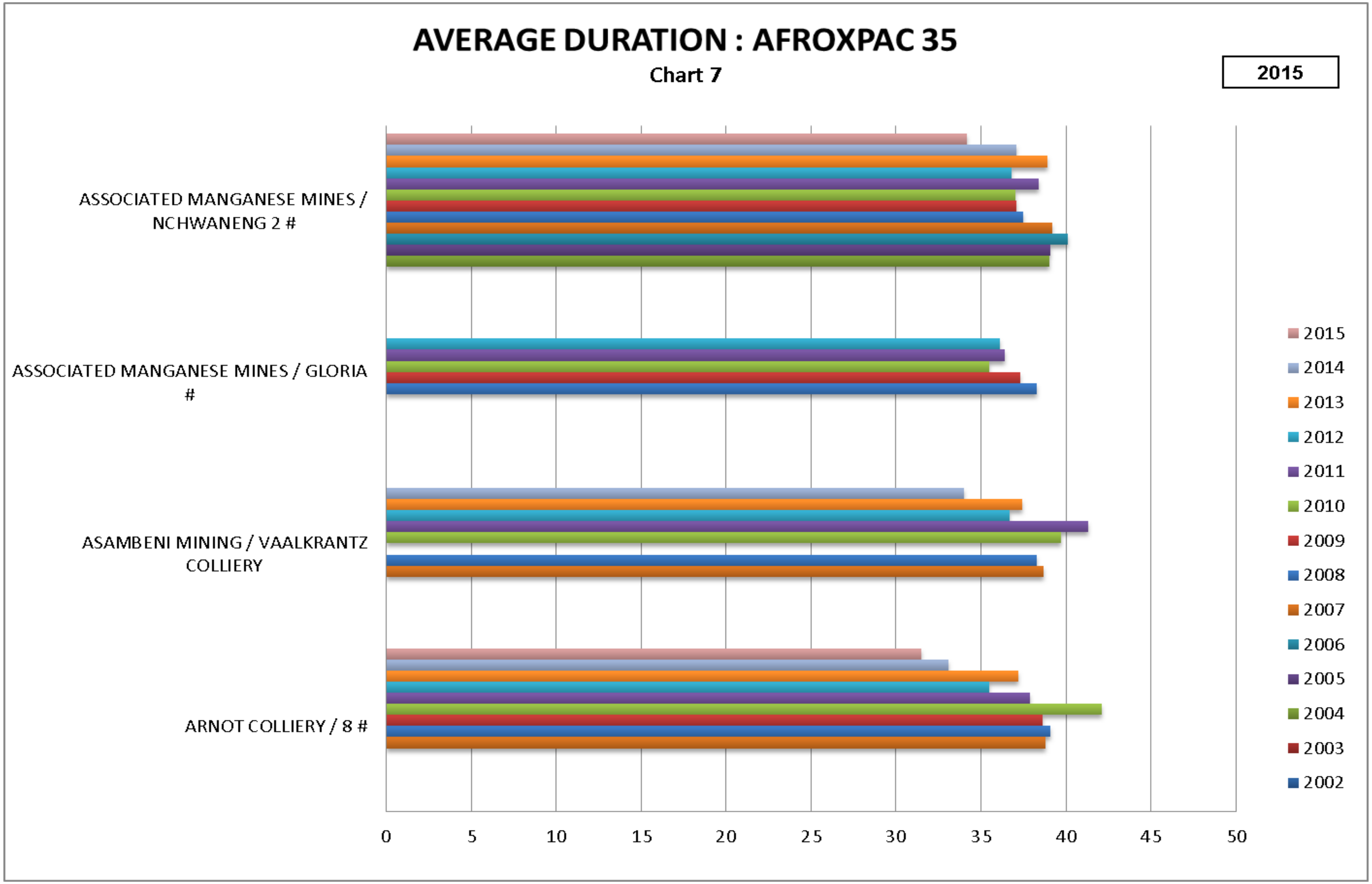

AVERAGE DURATION : AFROXPAC 35
Chart 2
2015
(2nd Test) BLYVOORUITZICHT GOLD MINE / 6 #
(2nd Test) BLYVOORUITZICHT GOLD MINE / 5 #
(2nd Test) BLYVOORUITZICHT GOLD MINE / 4 #
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002

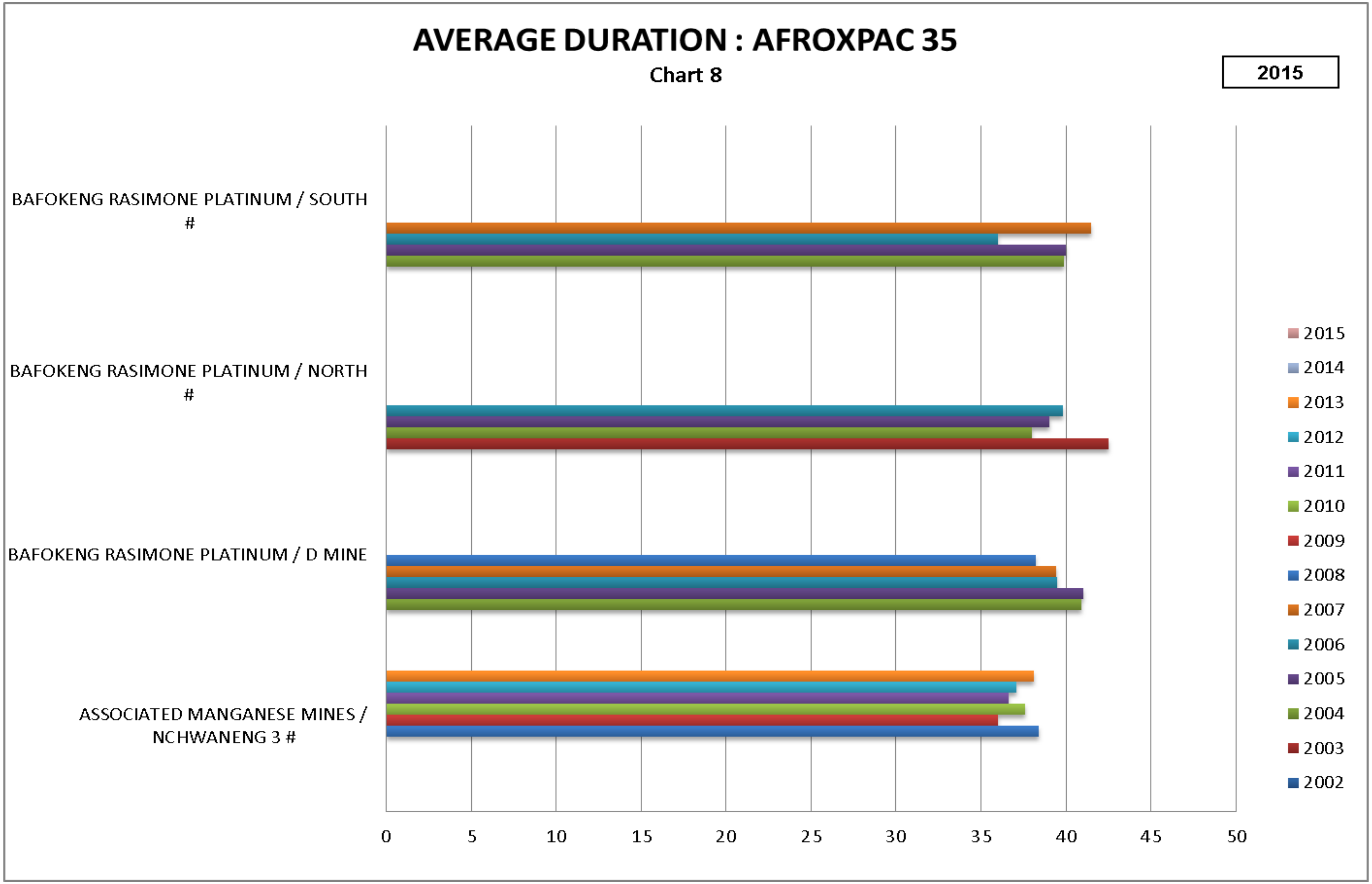

AVERAGE DURATION : AFROXPAC 35
Chart 3
2015
ANGLOPLATINUM / KOMANANI # (RPM-FRANK 1)
ANGLOPLATINUM / DISHABA-UPPER # (AMANDELBULT)
ANGLOPLATINUM / BATHOPELE # (RPM-WATERVAL)
SIBANYE GOLD / MODDER EAST
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002

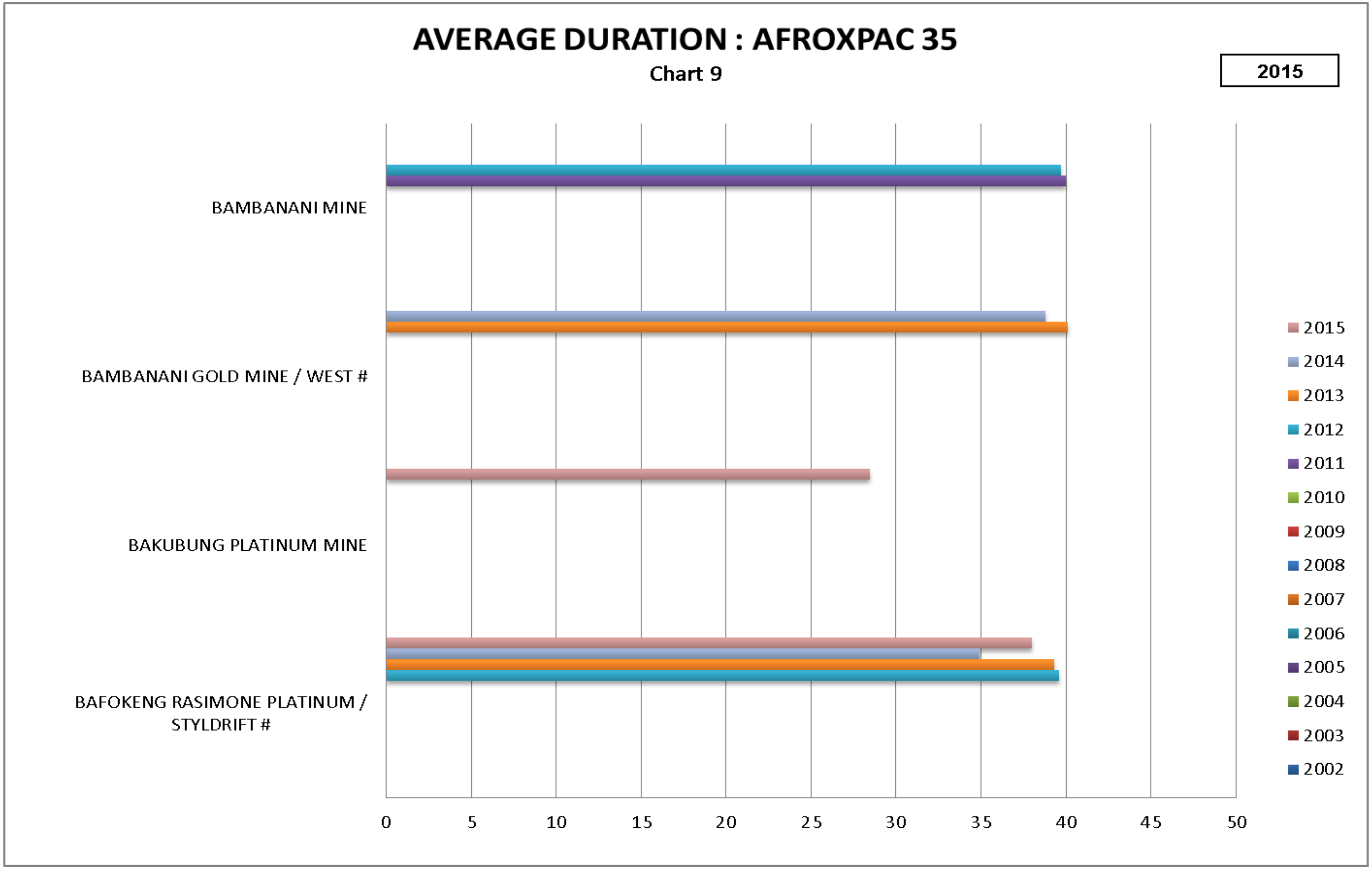

AVERAGE DURATION : AFROXPAC 35
Chart 4
2015
ANGLOPLATINUM / RPM-AMANDELBULT - SPECIAL TEST
ANGLOPLATINUM / RPM-AMANDELBULT - 43 EAST #
ANGLOPLATINUM / KUSELEKA # (RPM-TOWNLANDS)
ANGLOPLATINUM / KUSELEKA # (RPM-BOSCHFONTEIN)
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002


AVERAGE DURATION : AFROXPAC 35
Chart 5
2015
ANGLOPLATINUM / THEMBELANI # (RPM-PAARDEKRAAL)
ANGLOPLATINUM / SIPHUMELELA # (RPM-TURFONTEIN)
ANGLOPLATINUM / SIPHUMELELA # (RPM-BLESKOP)
ANGLOPLATINUM / RPM-FRANK 2 #
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002


AVERAGE DURATION : AFROXPAC 35
Chart 6
2015
ARNOT COLLIERY / 10 #
ANGLOPLATINUM / UNION-DECLINE 4B #
ANGLOPLATINUM / UNION-DECLINE 1 #
ANGLOPLATINUM / UNION-4 SOUTH #
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002


AVERAGE DURATION : AFROXPAC 35
Chart 7
2015
ASSOCIATED MANGANESE MINES / NCHWANENG 2 #
ASSOCIATED MANGANESE MINES / GLORIA #
ASAMBENI MINING / VAALKRANTZ COLLIERY
ARNOT COLLIERY / 8 #
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002


AVERAGE DURATION : AFROXPAC 35
Chart 8
2015
BAFOKENG RASIMONE PLATINUM / SOUTH #
BAFOKENG RASIMONE PLATINUM / NORTH #
BAFOKENG RASIMONE PLATINUM / D MINE
ASSOCIATED MANGANESE MINES / NCHWANENG 3 #
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002



AVERAGE DURATION : AFROXPAC 35
Chart 9
2015
BAMBANANI MINE
BAMBANANI GOLD MINE / WEST #
BAKUBUNG PLATINUM MINE
BAFOKENG RASIMONE PLATINUM / STYLDRIFT #
0
5
10
15
20
25
30
35
40
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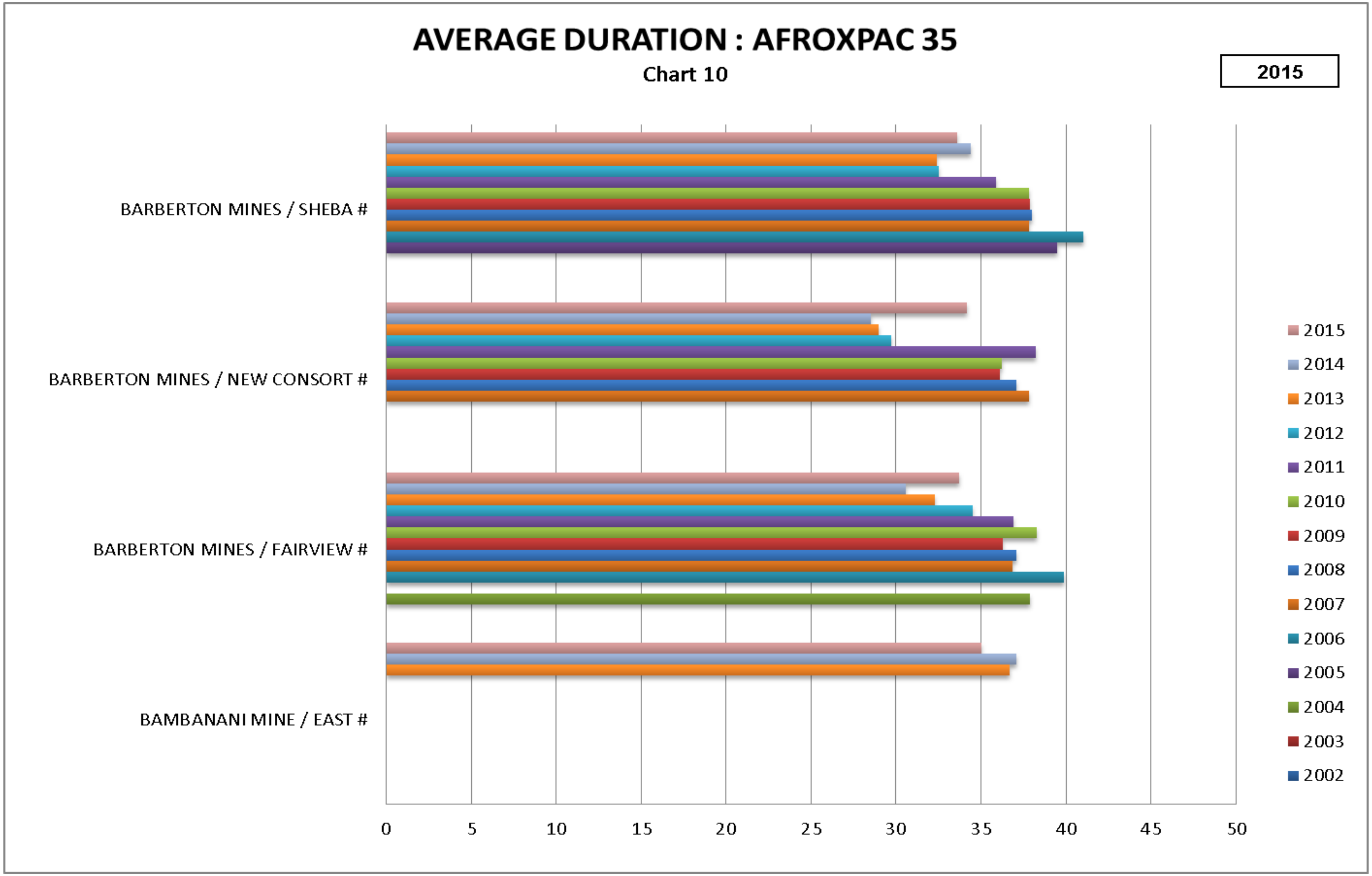
AVERAGE DURATION : AFROXPAC 35
Chart 10
2015
BARBERTON MINES / SHEBA #
BARBERTON MINES / NEW CONSORT #
BARBERTON MINES / FAIRVIEW #
BAMBANANI MINE / EAST #
0
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2015
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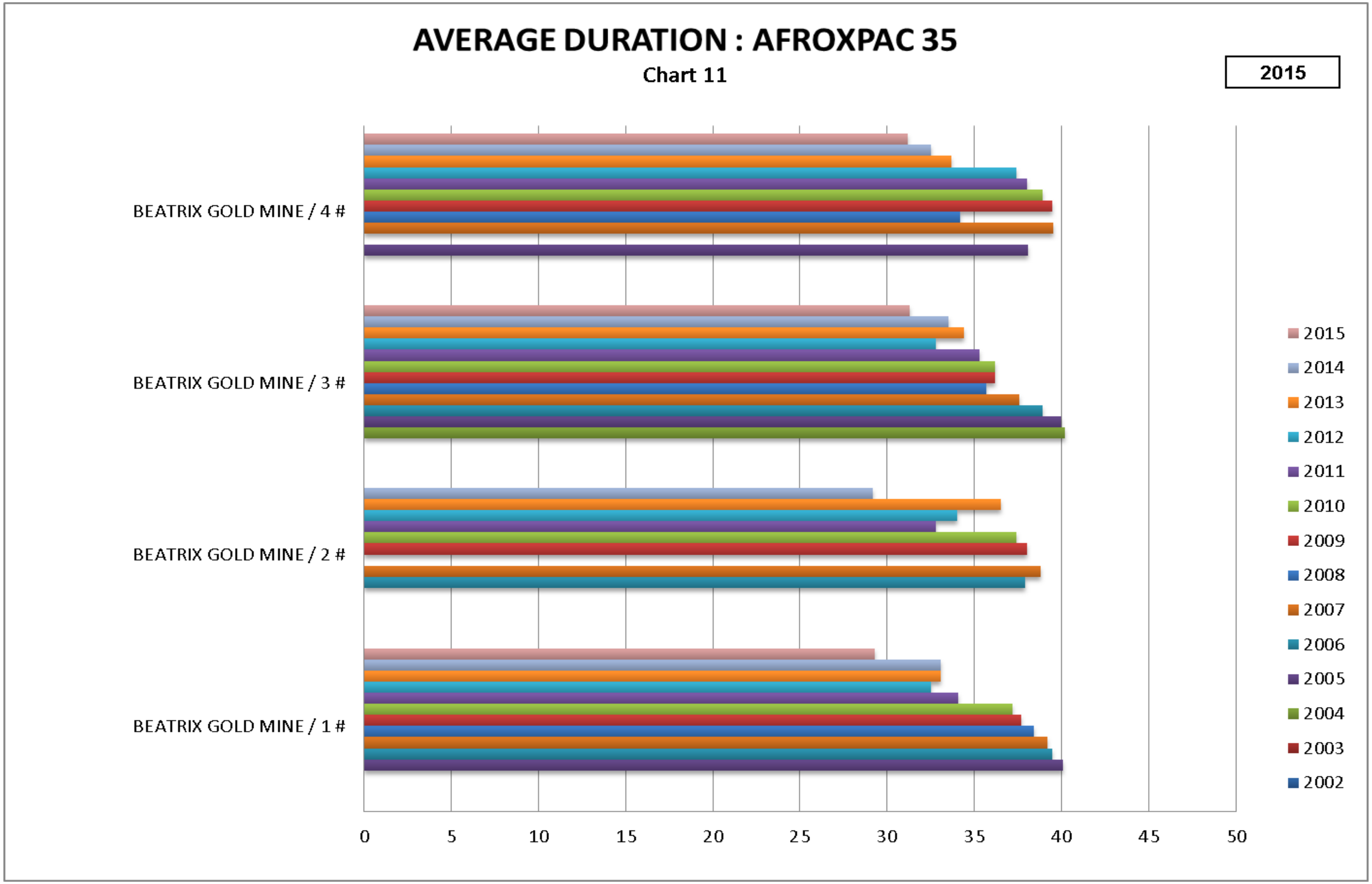
AVERAGE DURATION : AFROXPAC 35
Chart 11
2015
BEATRIX GOLD MINE / 4 #
BEATRIX GOLD MINE / 3 #
BEATRIX GOLD MINE / 2 #
BEATRIX GOLD MINE / 1 #
0
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2015
2014
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2011
2010
2009
2008
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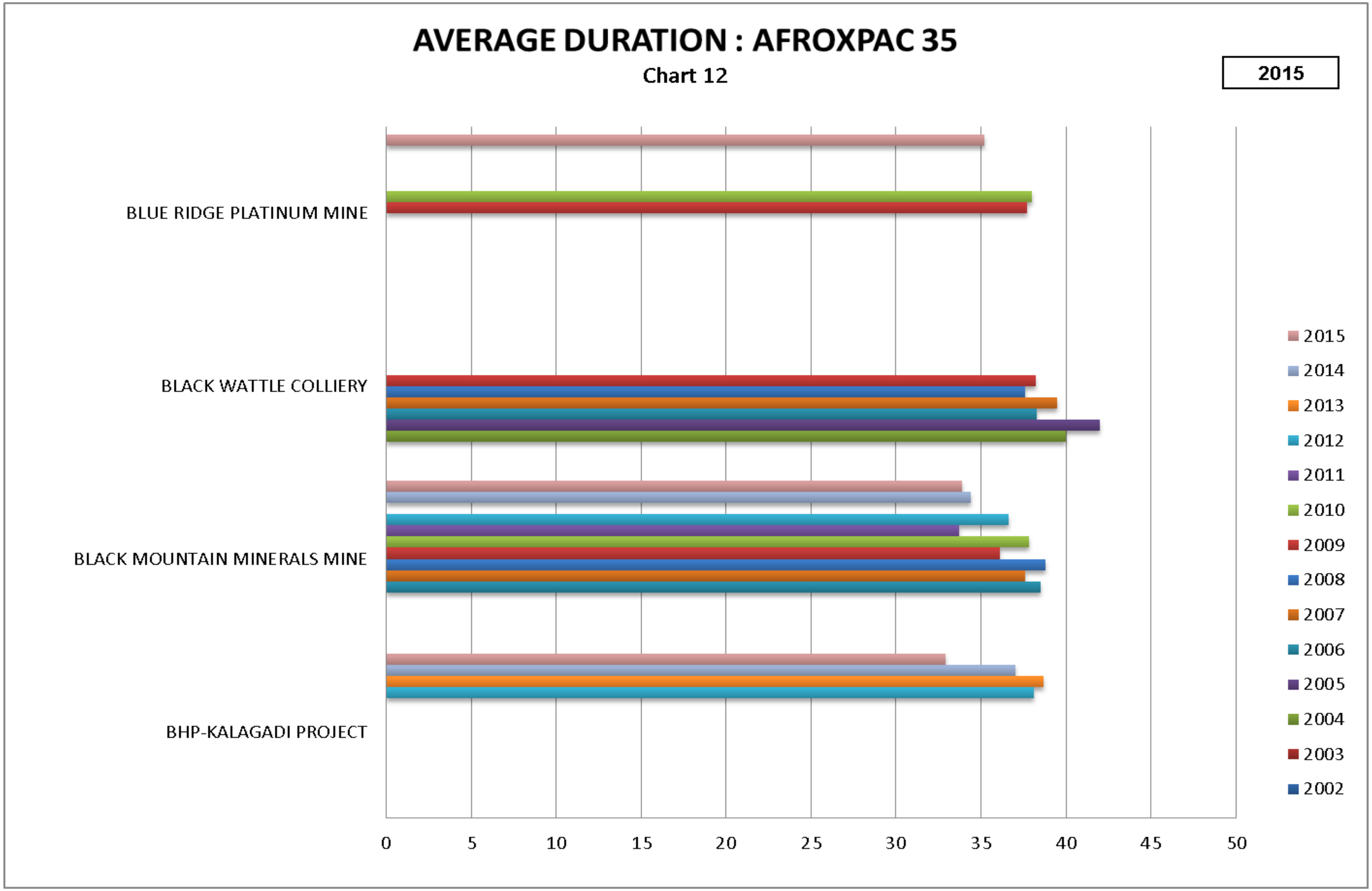
AVERAGE DURATION : AFROXPAC 35
Chart 12
2015
BLUE RIDGE PLATINUM MINE
BLACK WATTLE COLLIERY
BLACK MOUNTAIN MINERALS MINE
BHP-KALAGADI PROJECT
0
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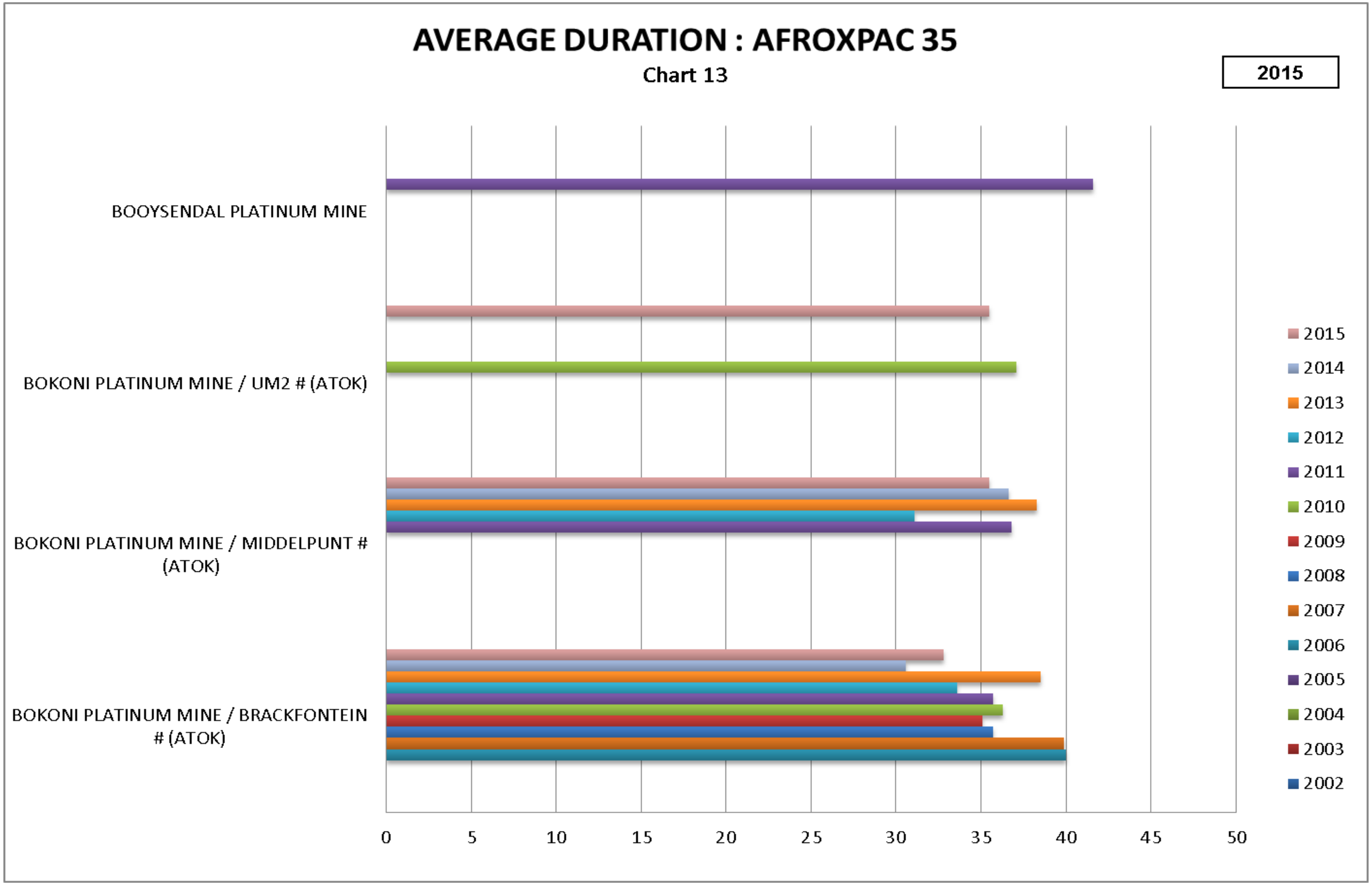
AVERAGE DURATION : AFROXPAC 35
Chart 13
2015
BOOYSENDAL PLATINUM MINE
BOKONI PLATINUM MINE / UM2 # (ATOK)
BOKONI PLATINUM MINE / MIDDELPUNT # (ATOK)
BOKONI PLATINUM MINE / BRACKFONTEIN # (ATOK)
0
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2015
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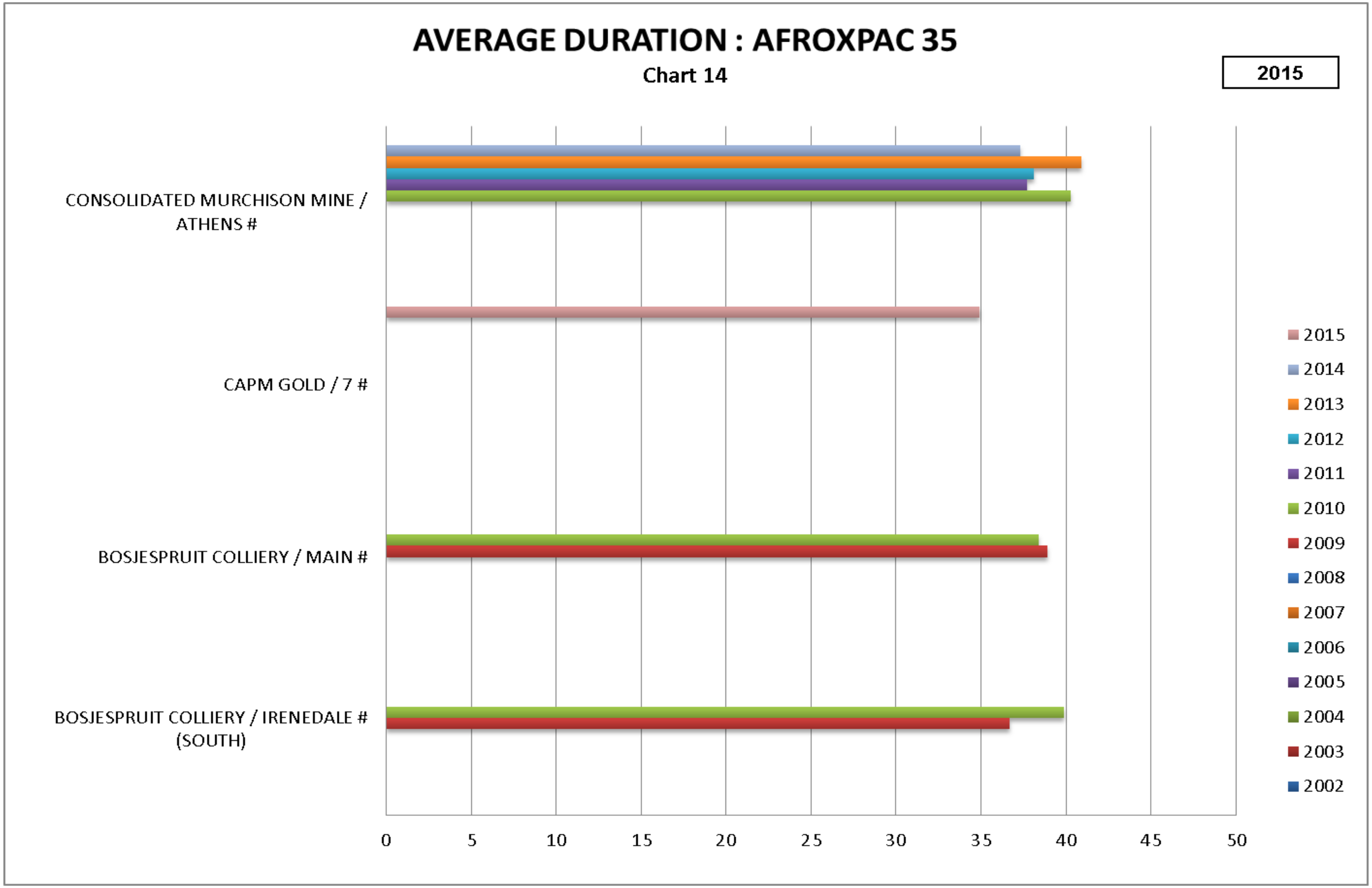
AVERAGE DURATION : AFROXPAC 35
Chart 14
2015
CONSOLIDATED MURCHISON MINE / ATHENS #
CAPM GOLD / 7 #
BOSJESPRUIT COLLIERY / MAIN #
BOSJESPRUIT COLLIERY / IRENEDALE # (SOUTH)
0
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2010
2009
2008
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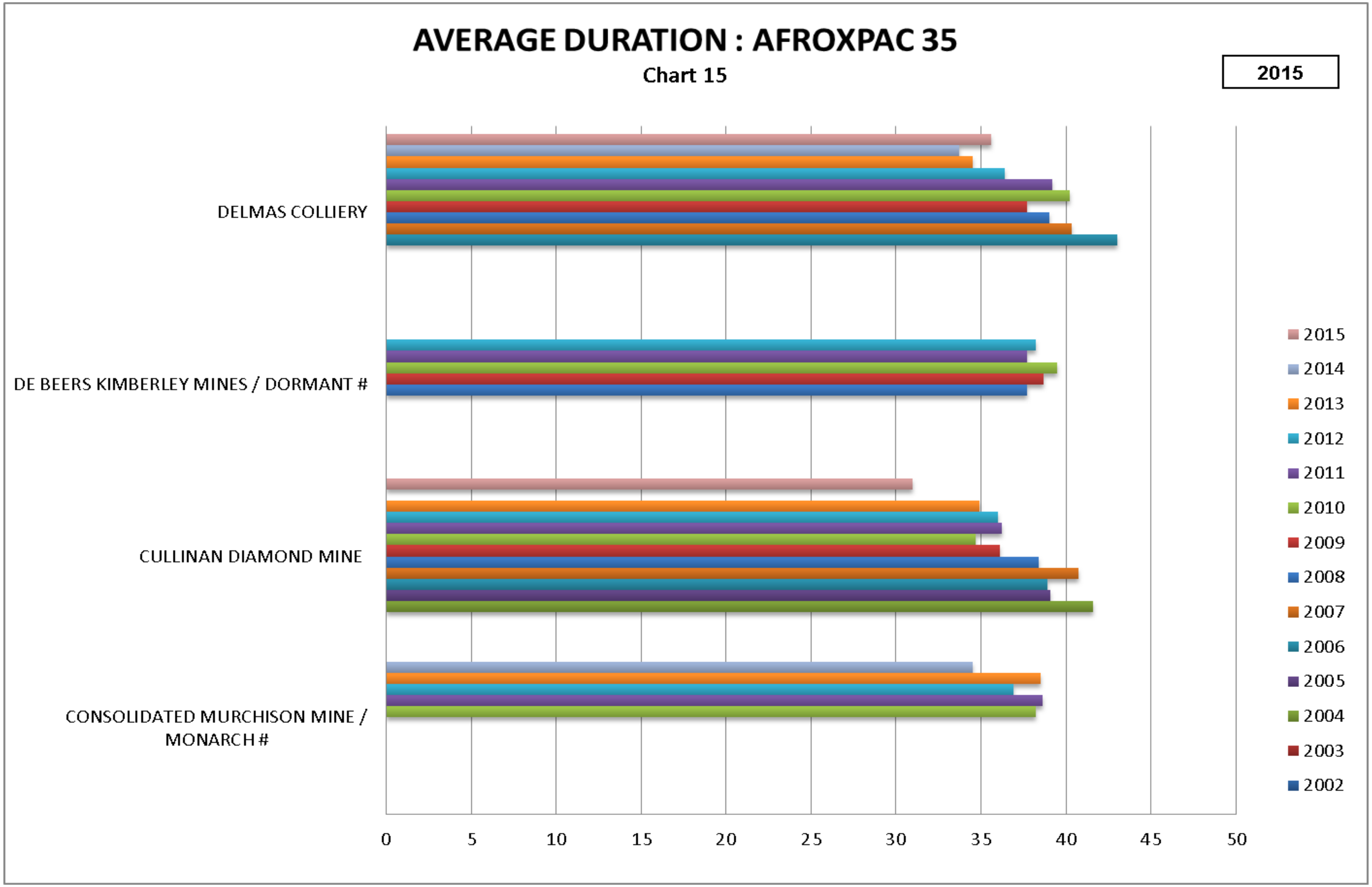
AVERAGE DURATION : AFROXPAC 35
Chart 15
2015
DELMAS COLLIERY
DE BEERS KIMBERLEY MINES / DORMANT #
CULLINAN DIAMOND MINE
CONSOLIDATED MURCHISON MINE / MONARCH #
0
5
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2009
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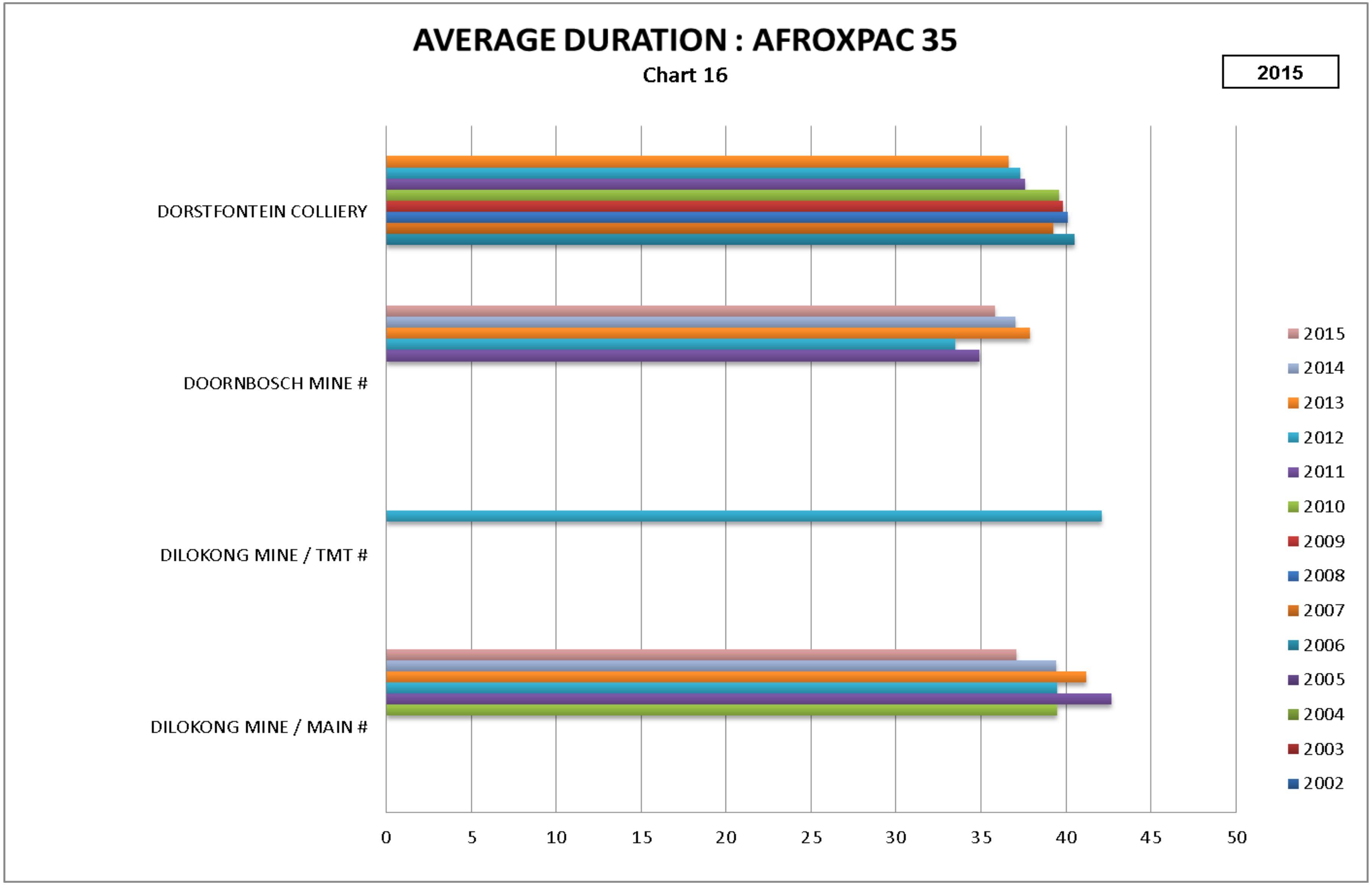
AVERAGE DURATION : AFROXPAC 35
Chart 16
2015
DORSTFONTEIN COLLIERY
DOORNBOSCH MINE #
DILOKONG MINE / TMT #
DILOKONG MINE / MAIN #
0
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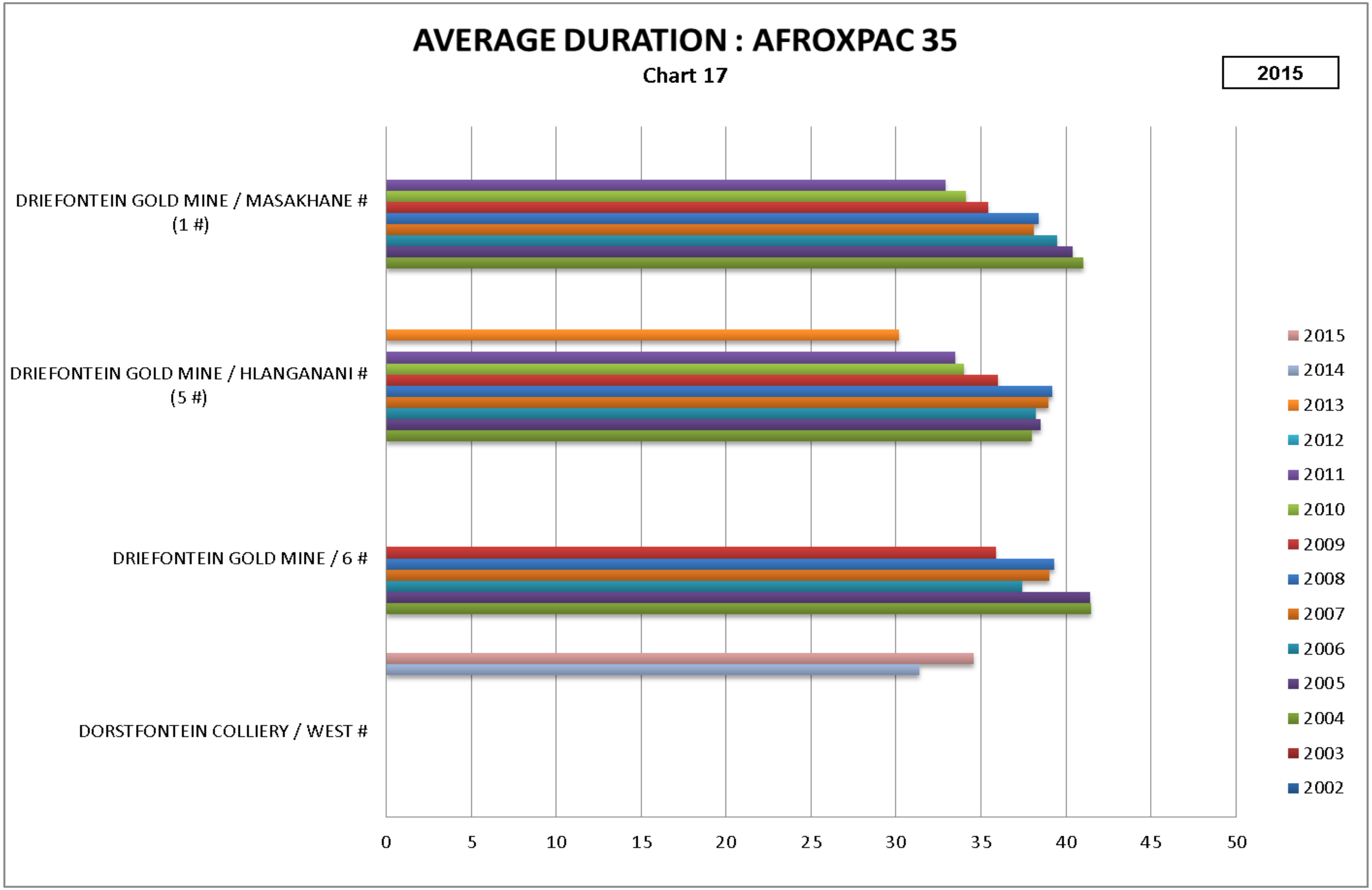

AVERAGE DURATION : AFROXPAC 35
Chart 17
2015
DRIEFONTEIN GOLD MINE / MASAKHANE # (1 #)
DRIEFONTEIN GOLD MINE / HLANGANANI # (5 #)
DRIEFONTEIN GOLD MINE / 6 #
DORSTFONTEIN COLLIERY / WEST #
0
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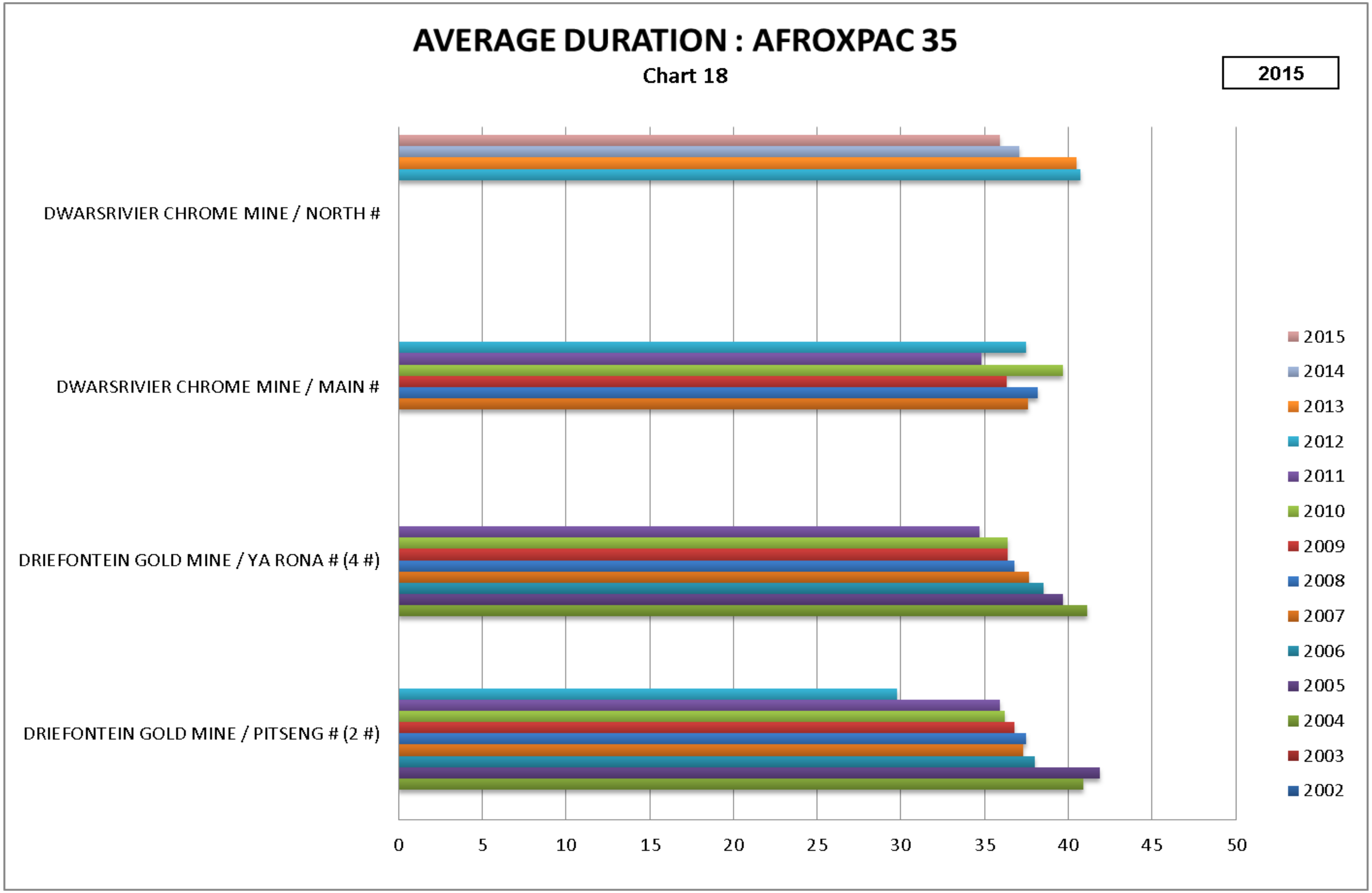
AVERAGE DURATION : AFROXPAC 35
Chart 18
2015
DWARSRIVIER CHROME MINE / NORTH #
DWARSRIVIER CHROME MINE / MAIN #
DRIEFONTEIN GOLD MINE / YA RONA # (4 #)
DRIEFONTEIN GOLD MINE / PITSENG # (2 #)
0
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2015
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2009
2008
2007
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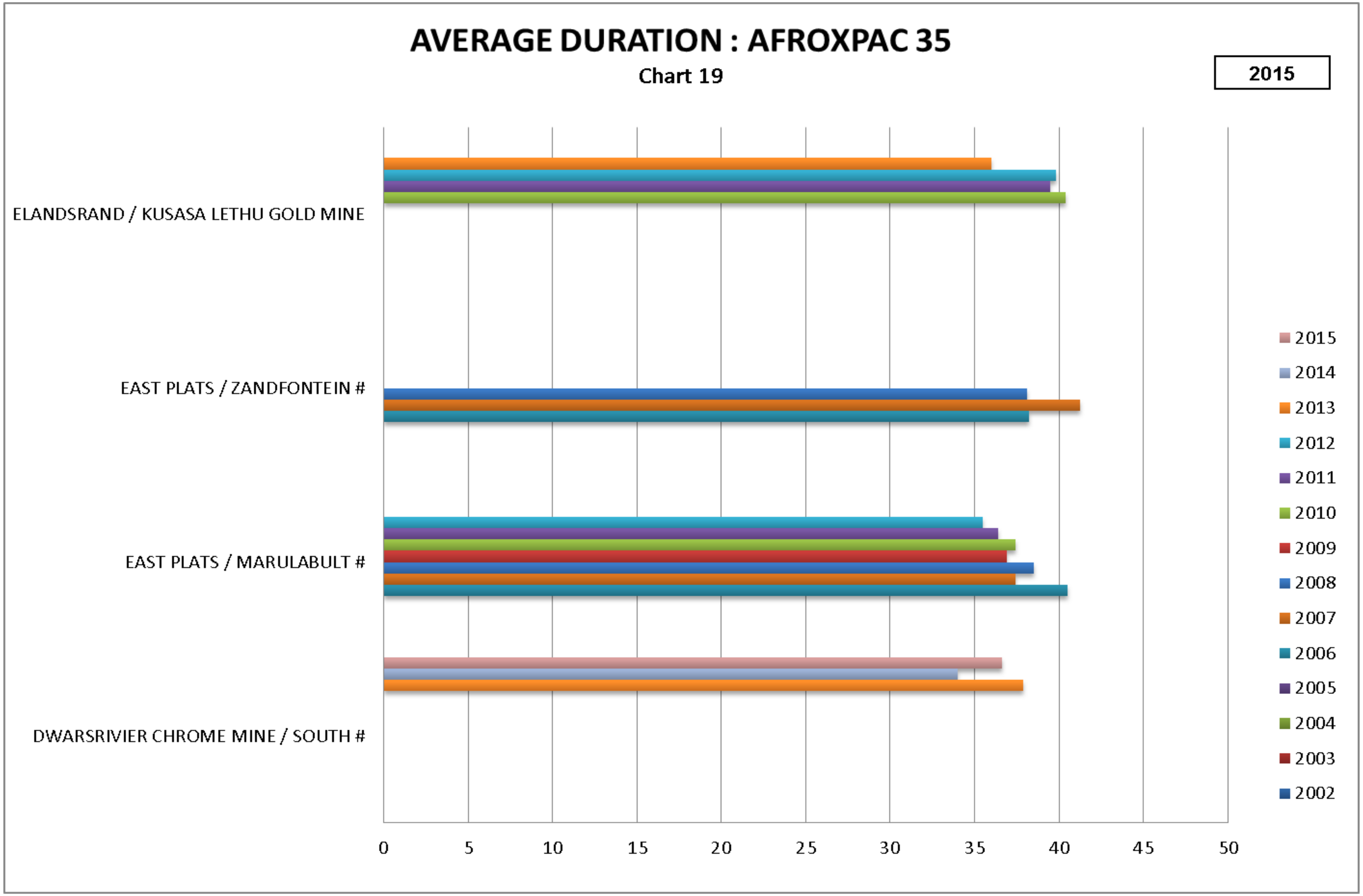
2002


AVERAGE DURATION : AFROXPAC 35
Chart 19
2015
ELANDSRAND / KUSASA LETHU GOLD MINE
EAST PLATS / ZANDFONTEIN #
EAST PLATS / MARULABULT #
DWARSRIVIER CHROME MINE / SOUTH #
0
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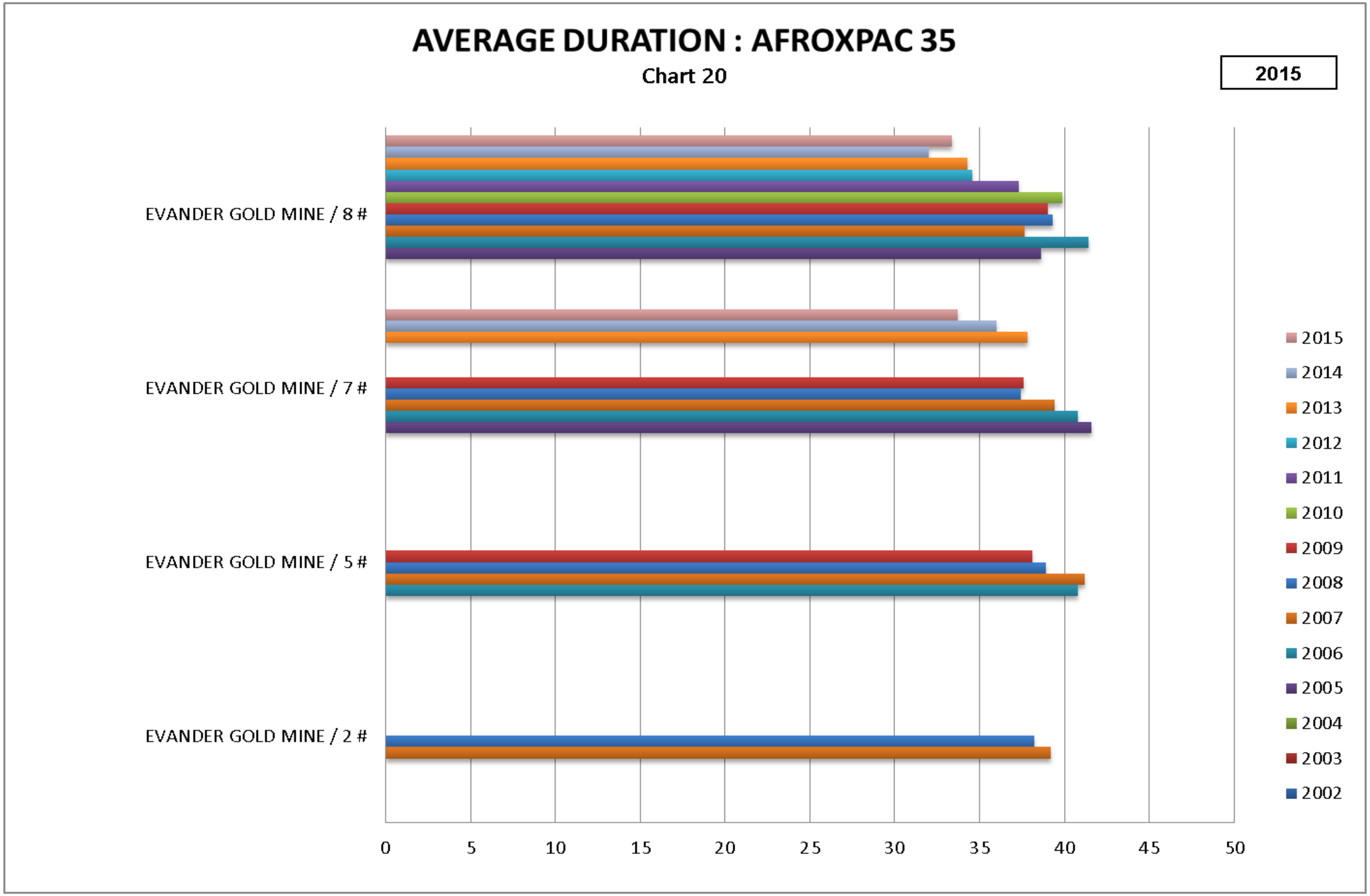
AVERAGE DURATION : AFROXPAC 35
Chart 20
2015
EVANDER GOLD MINE / 8 #
EVANDER GOLD MINE / 7 #
EVANDER GOLD MINE / 5 #
EVANDER GOLD MINE / 2 #
0
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2015
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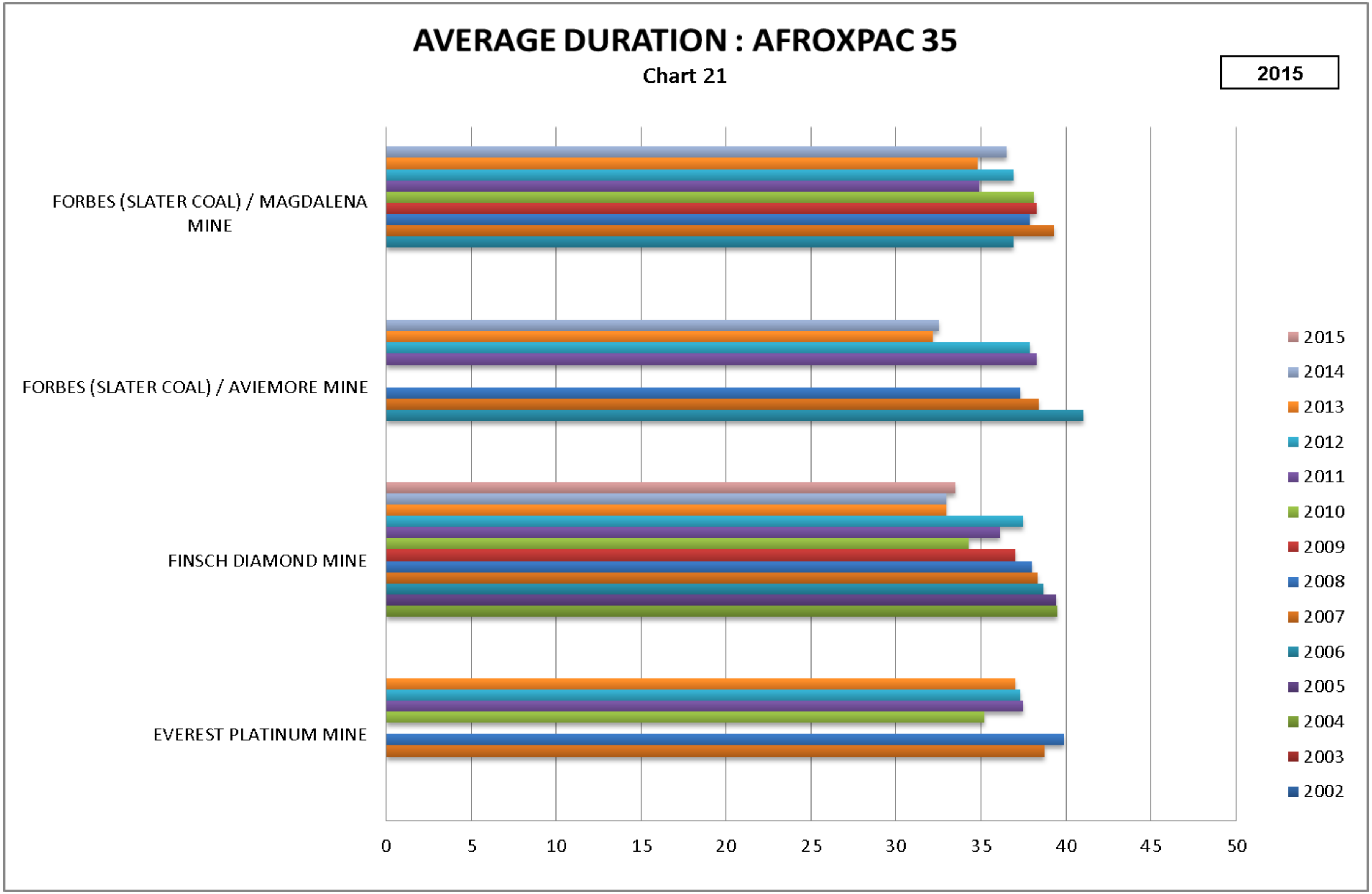

AVERAGE DURATION : AFROXPAC 35
Chart 21
2015
FORBES (SLATER COAL) / MAGDALENA MINE
FORBES (SLATER COAL) / AVIEMORE MINE
FINSCH DIAMOND MINE
EVEREST PLATINUM MINE
0
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2008
2007
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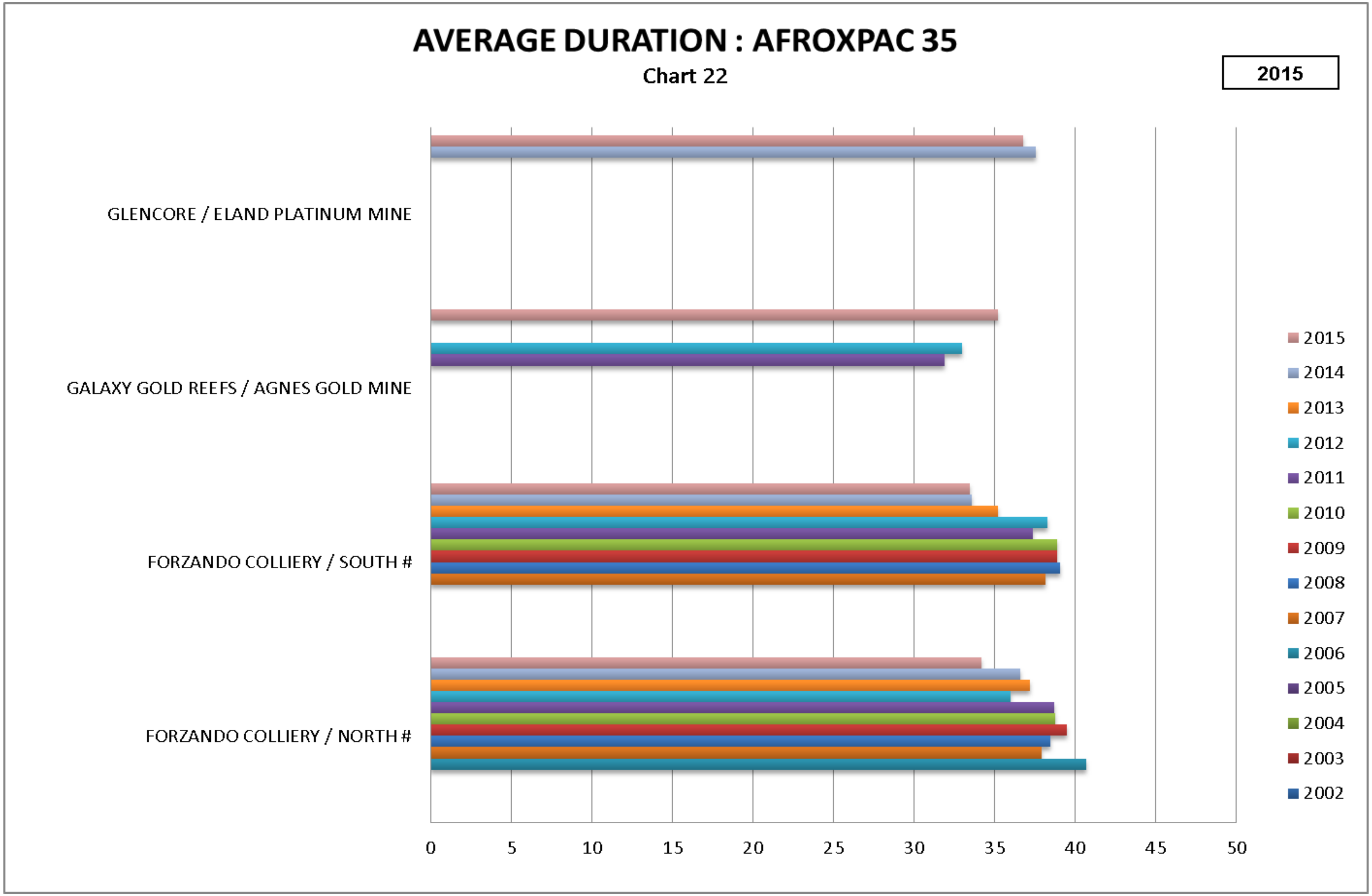
AVERAGE DURATION : AFROXPAC 35
Chart 22
2015
GLENCORE / ELAND PLATINUM MINE
GALAXY GOLD REEFS / AGNES GOLD MINE
FORZANDO COLLIERY / SOUTH #
FORZANDO COLLIERY / NORTH #
0
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2015
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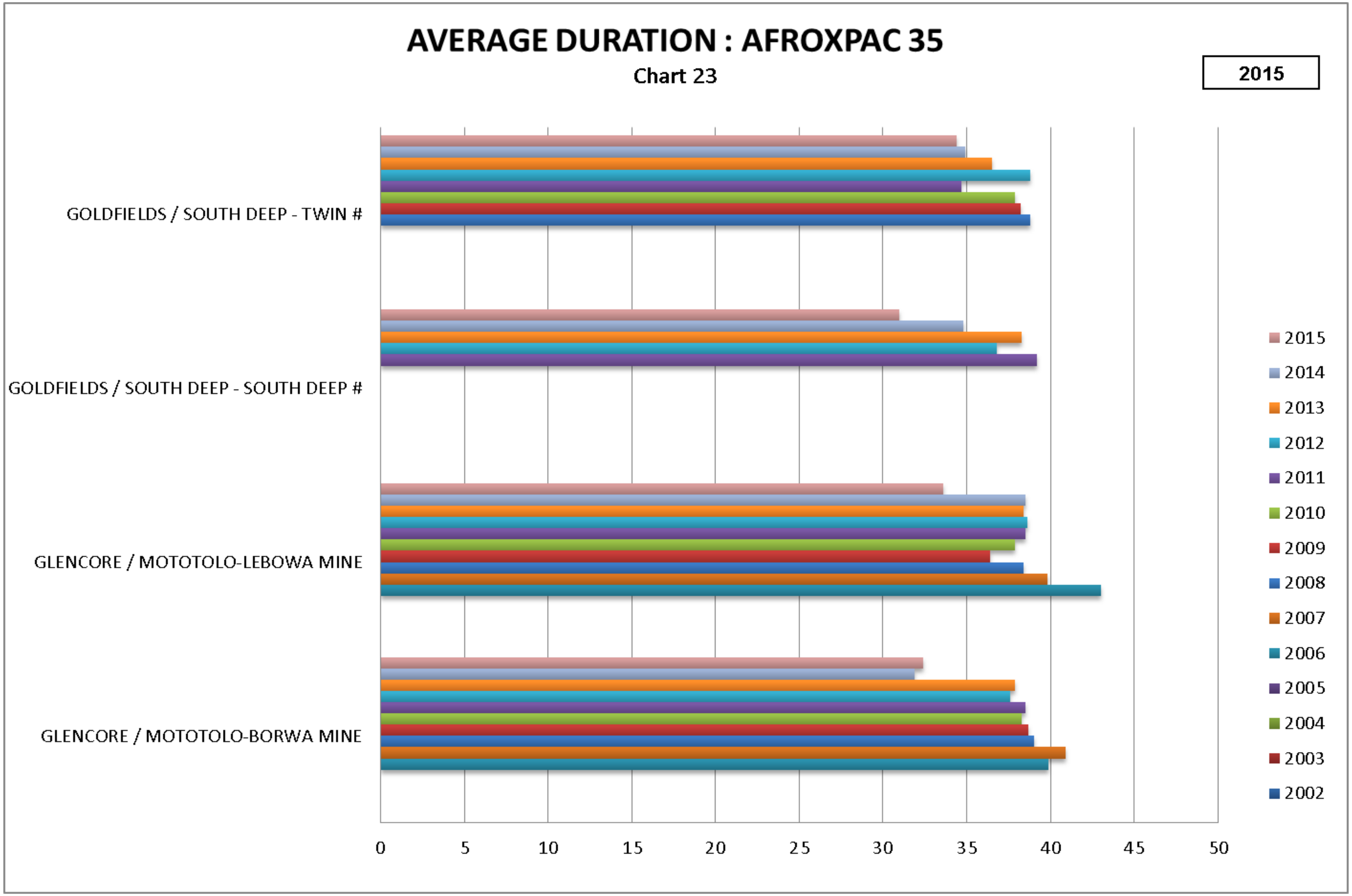
AVERAGE DURATION : AFROXPAC 35
Chart 23
2015
GOLDFIELDS / SOUTH DEEP - TWIN #
GOLDFIELDS / SOUTH DEEP - SOUTH DEEP #
GLENCORE / MOTOTOLO-LEBOWA MINE
GLENCORE / MOTOTOLO-BORWA MINE
0
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2010
2009
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2007
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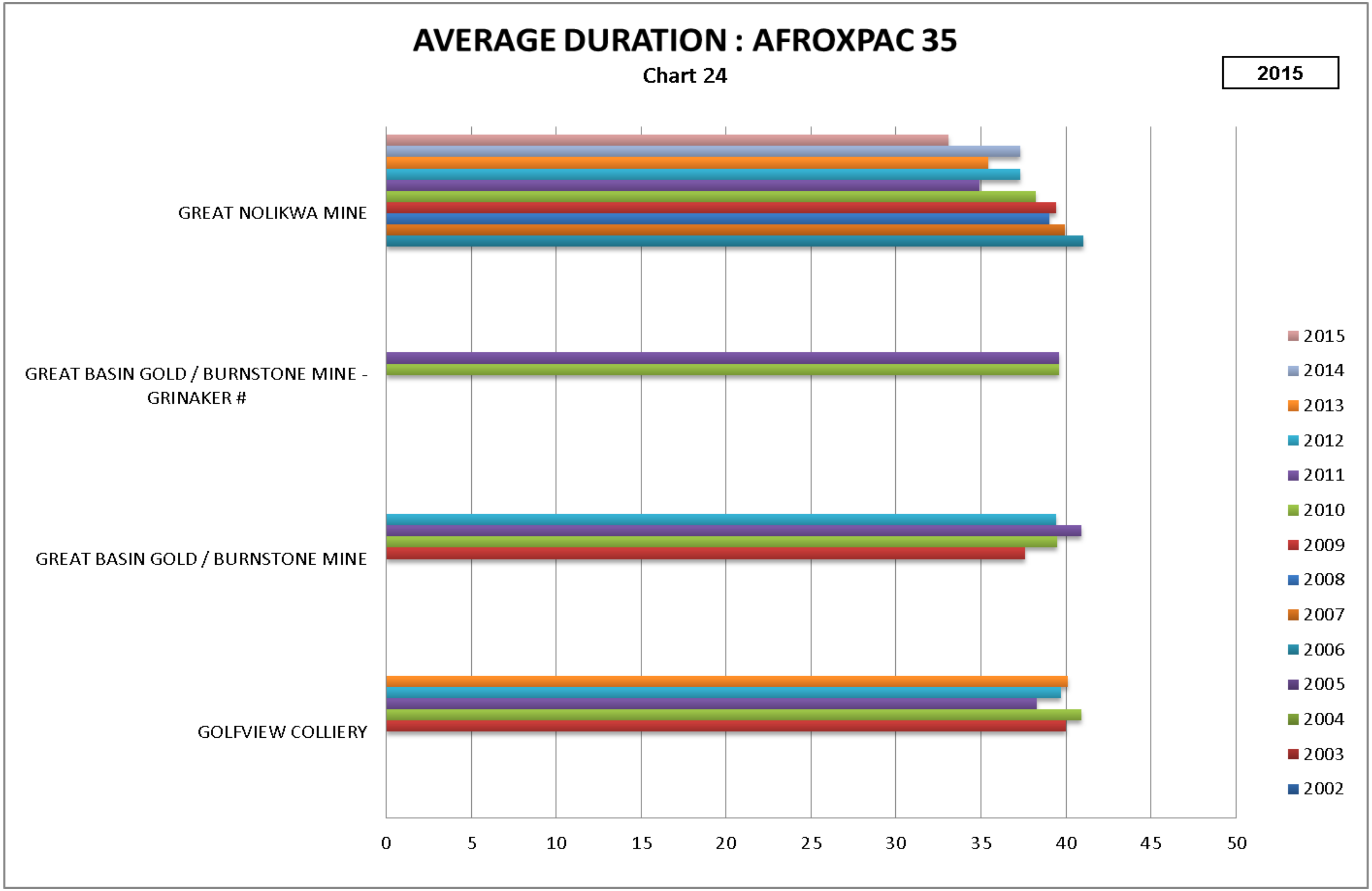
AVERAGE DURATION : AFROXPAC 35
Chart 24
2015
GREAT NOLIKWA MINE
GREAT BASIN GOLD / BURNSTONE MINE - GRINAKER #
GREAT BASIN GOLD / BURNSTONE MINE
GOLFVIEW COLLIERY
0
5
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2015
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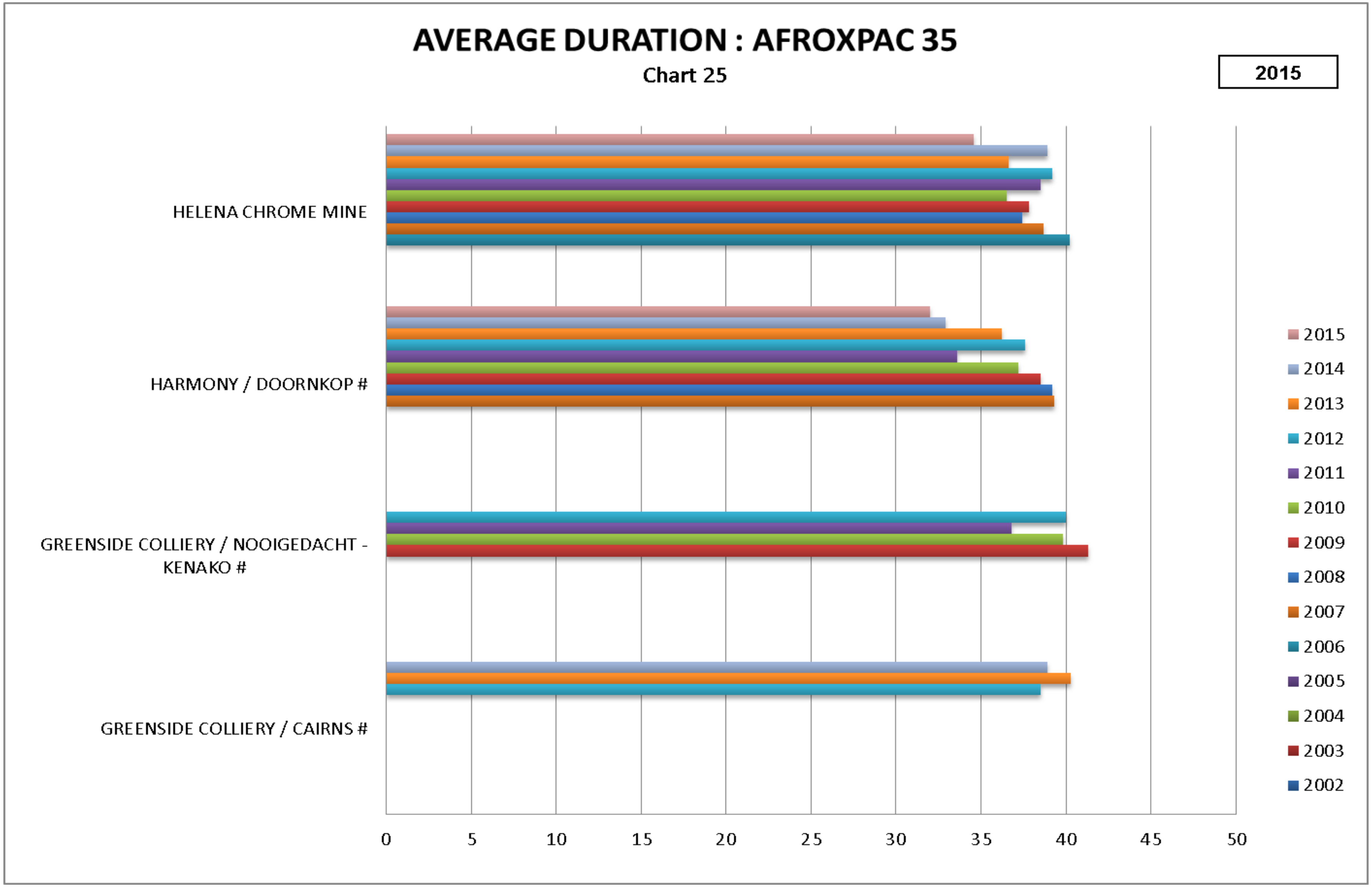
AVERAGE DURATION : AFROXPAC 35
Chart 25
2015
HELENA CHROME MINE
HARMONY / DOORNKOP #
GREENSIDE COLLIERY / NOOIGEDACHT - KENAKO #
GREENSIDE COLLIERY / CAIRNS #
0
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2009
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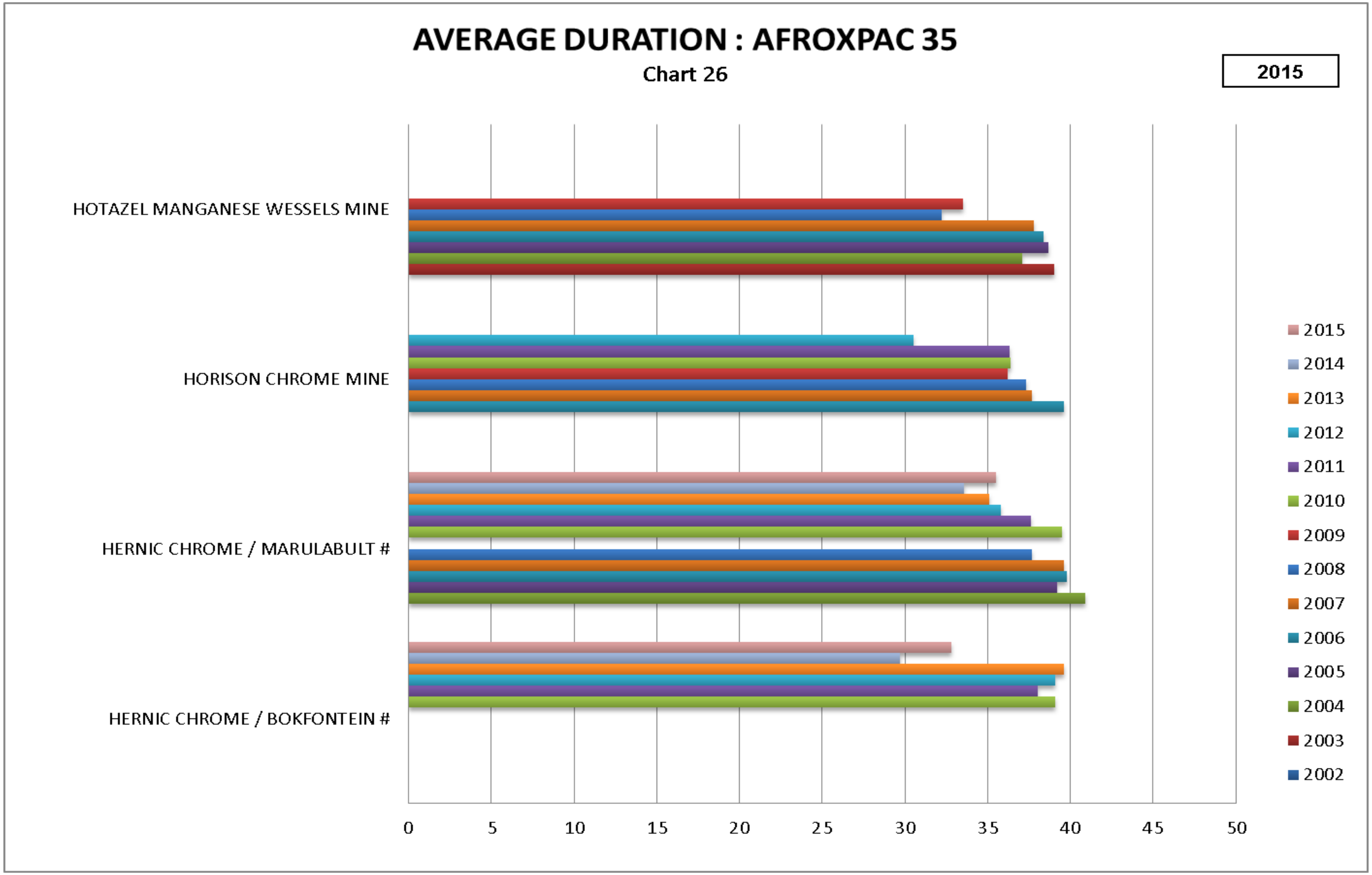
AVERAGE DURATION : AFROXPAC 35
Chart 26
2015
HOTAZEL MANGANESE WESSELS MINE
HORISON CHROME MINE
HERNIC CHROME / MARULABULT #
HERNIC CHROME / BOKFONTEIN #
0
5
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45
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2015
2014
2013
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2011
2010
2009
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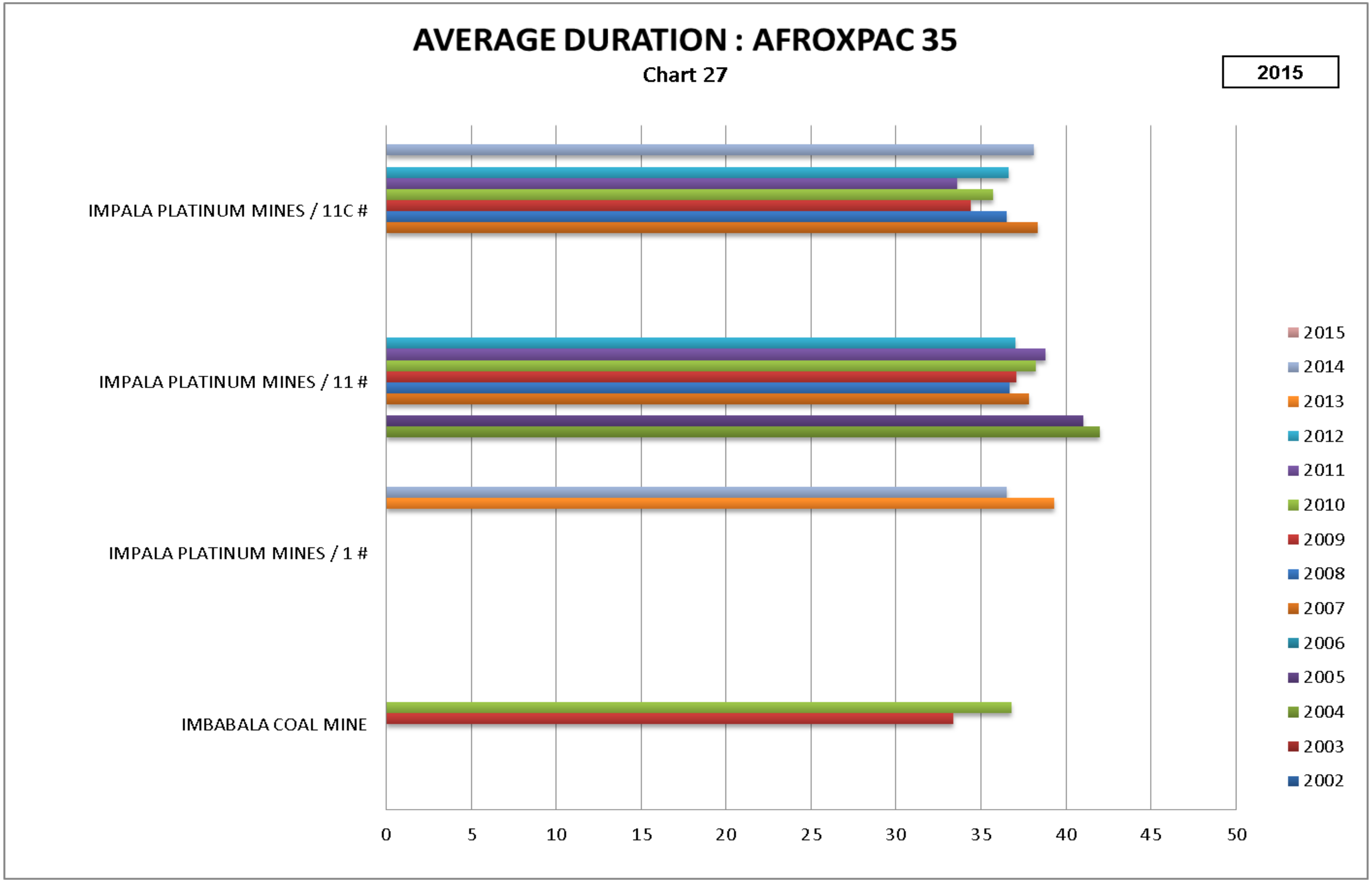

AVERAGE DURATION : AFROXPAC 35
Chart 27
2015
IMPALA PLATINUM MINES / 11C #
IMPALA PLATINUM MINES / 11 #
IMPALA PLATINUM MINES / 1 #
IMBABALA COAL MINE
0
5
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2015
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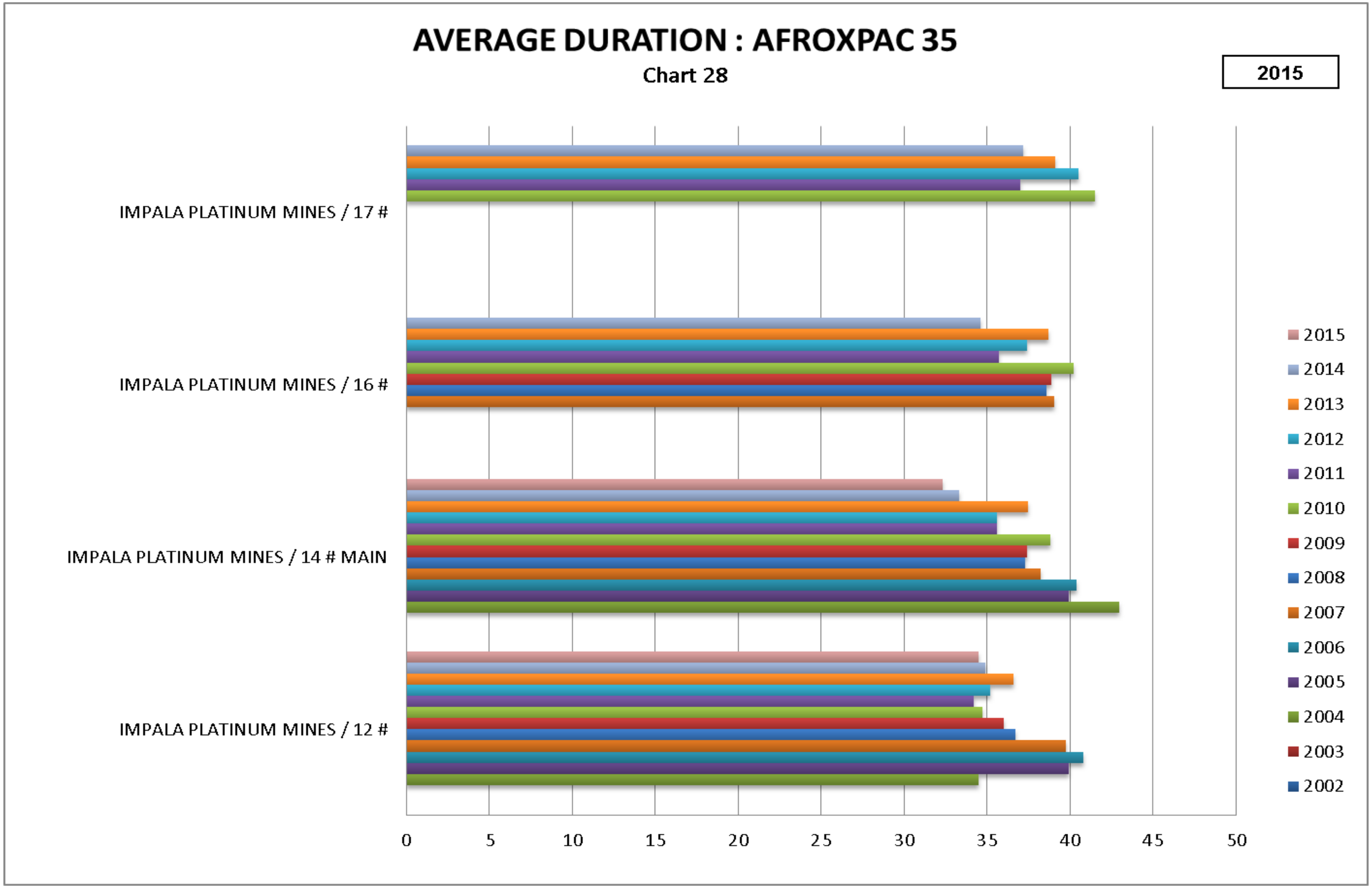
AVERAGE DURATION : AFROXPAC 35
Chart 28
2015
IMPALA PLATINUM MINES / 17 #
IMPALA PLATINUM MINES / 16 #
IMPALA PLATINUM MINES / 14 # MAIN
IMPALA PLATINUM MINES / 12 #
0
5
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2015
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2011
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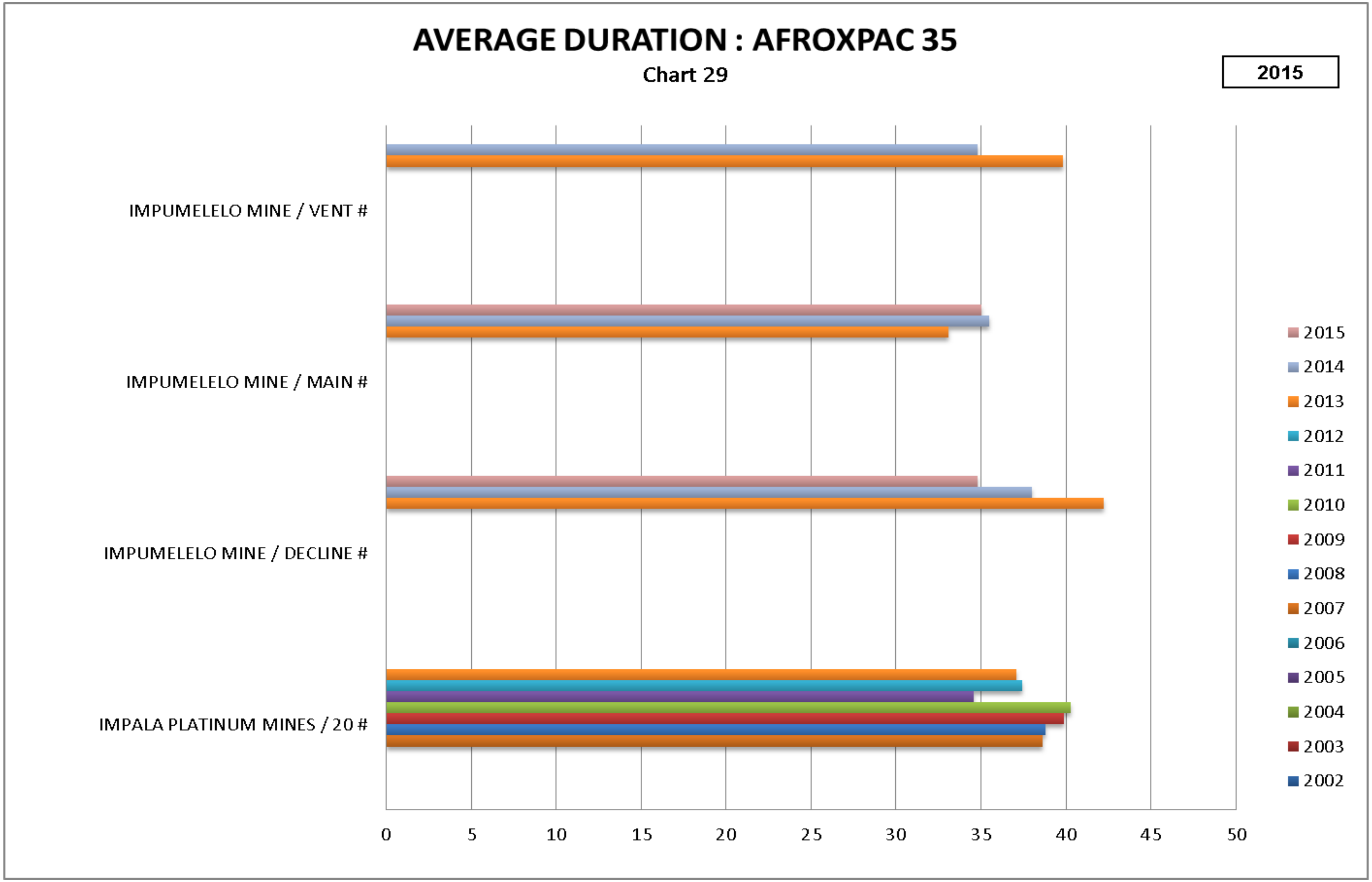
AVERAGE DURATION : AFROXPAC 35
Chart 29
2015
IMPUMELELO MINE / VENT #
IMPUMELELO MINE / MAIN #
IMPUMELELO MINE / DECLINE #
IMPALA PLATINUM MINES / 20 #
0
5
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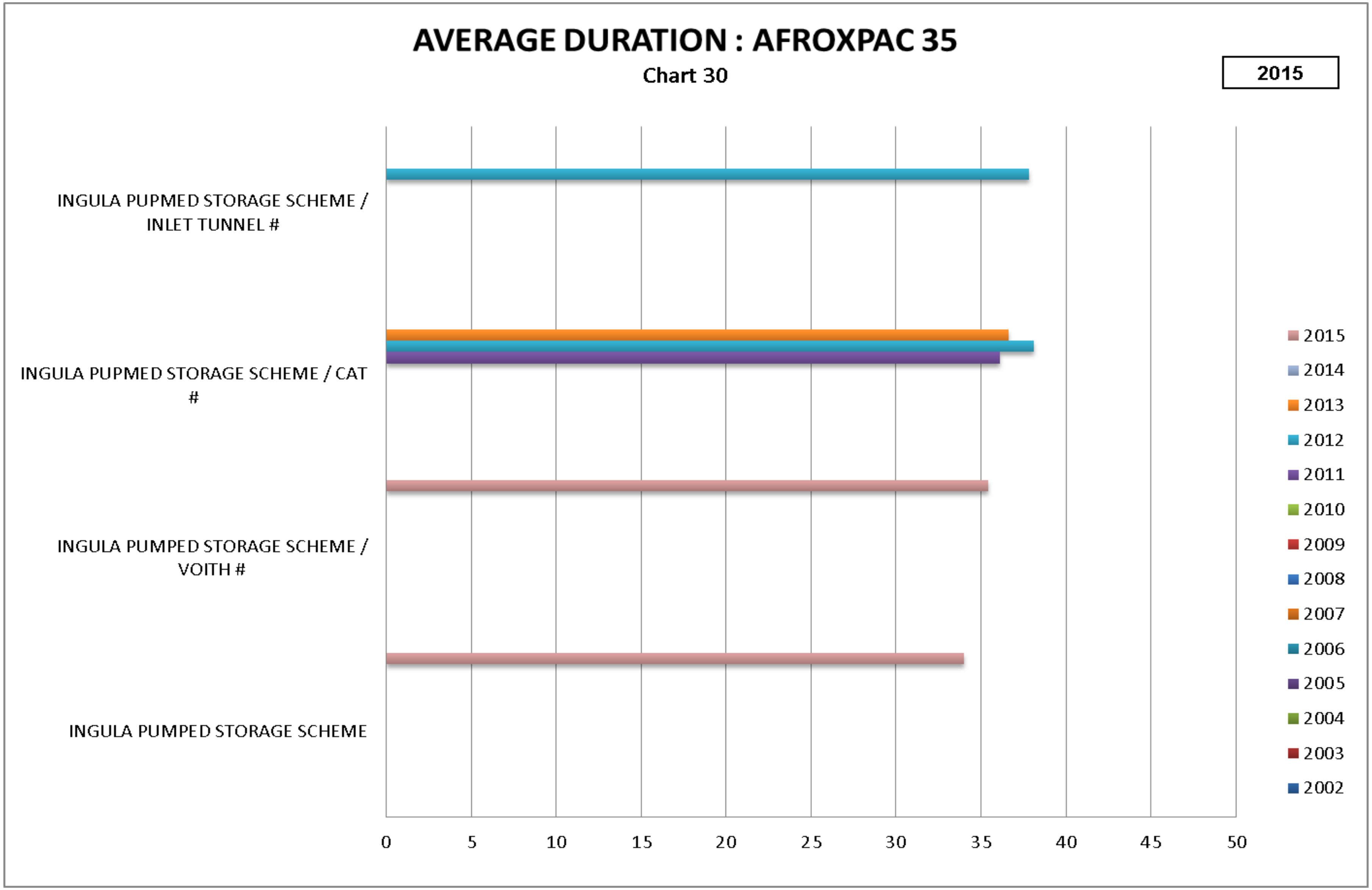
AVERAGE DURATION : AFROXPAC 35
Chart 30
2015
INGULA PUPMED STORAGE SCHEME / INLET TUNNEL #
INGULA PUPMED STORAGE SCHEME / CAT #
INGULA PUMPED STORAGE SCHEME / VOITH #
INGULA PUMPED STORAGE SCHEME
0
5
10
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2015
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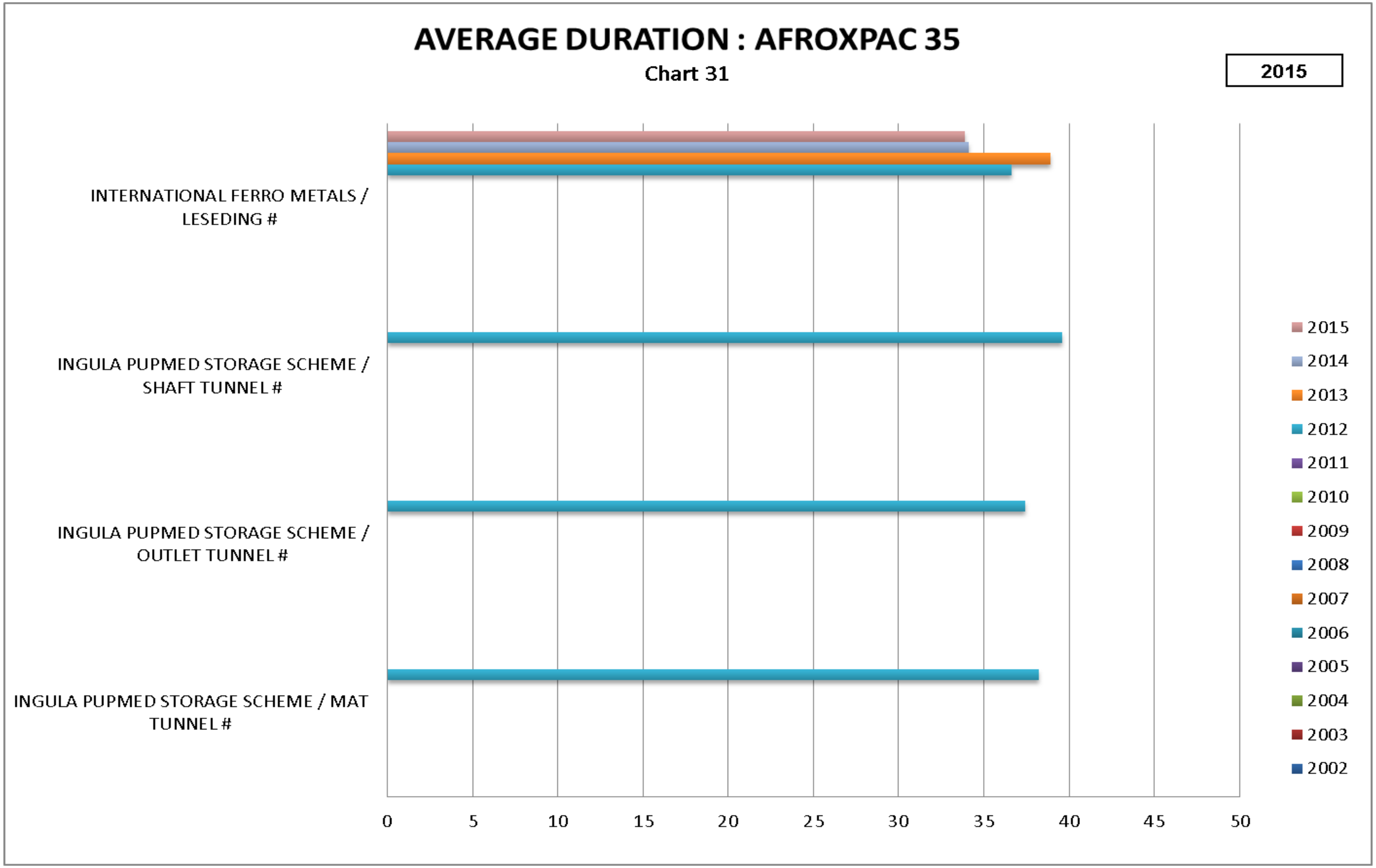
AVERAGE DURATION : AFROXPAC 35
Chart 31
2015
INTERNATIONAL FERRO METALS / LESEDING #
INGULA PUPMED STORAGE SCHEME / SHAFT TUNNEL #
INGULA PUPMED STORAGE SCHEME / OUTLET TUNNEL #
INGULA PUPMED STORAGE SCHEME / MAT TUNNEL #
0
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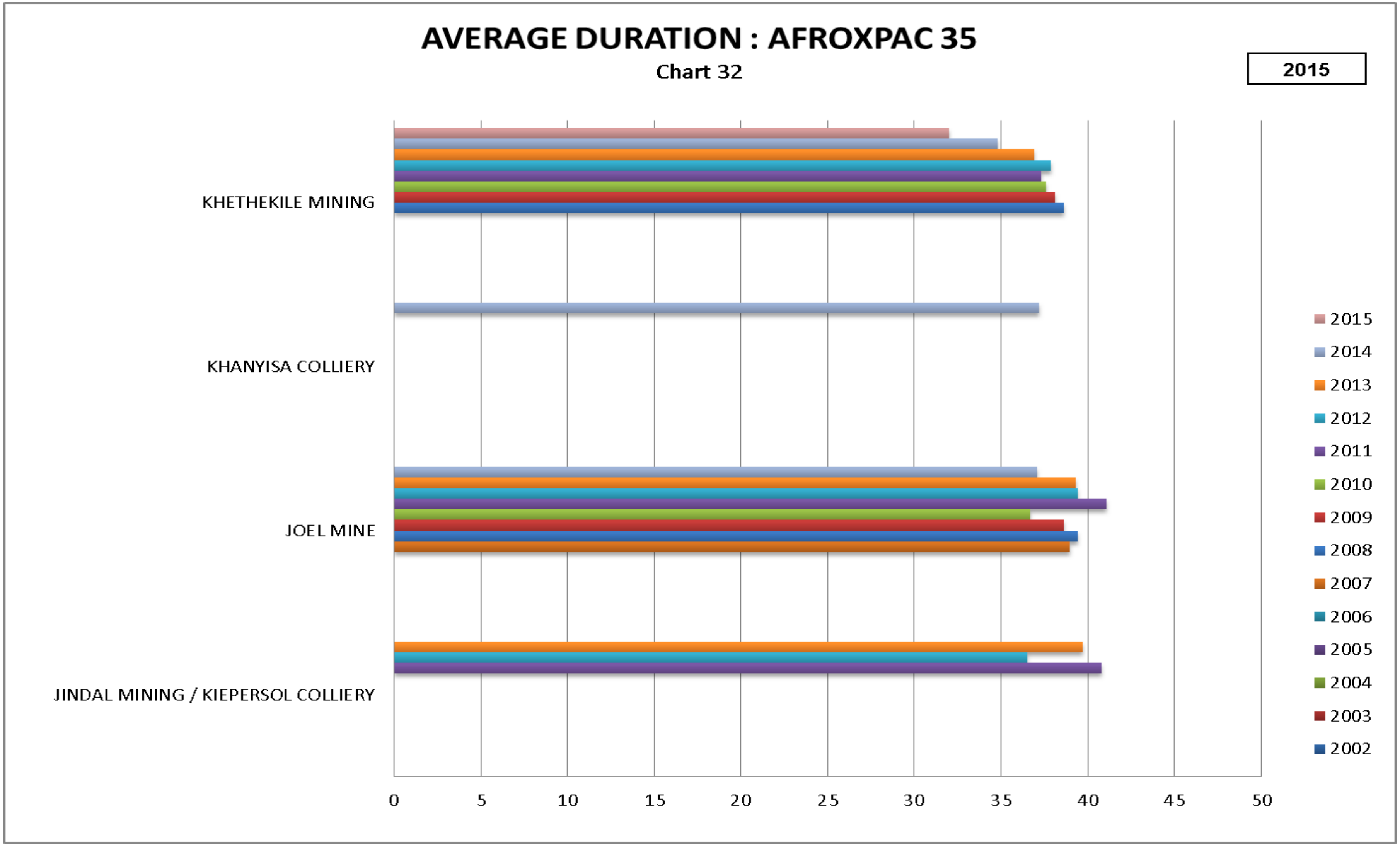

AVERAGE DURATION : AFROXPAC 35
Chart 32
2015
KHETHEKILE MINING
KHANYISA COLLIERY
JOEL MINE
JINDAL MINING / KIEPERSOL COLLIERY
0
5
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15
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25
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2015
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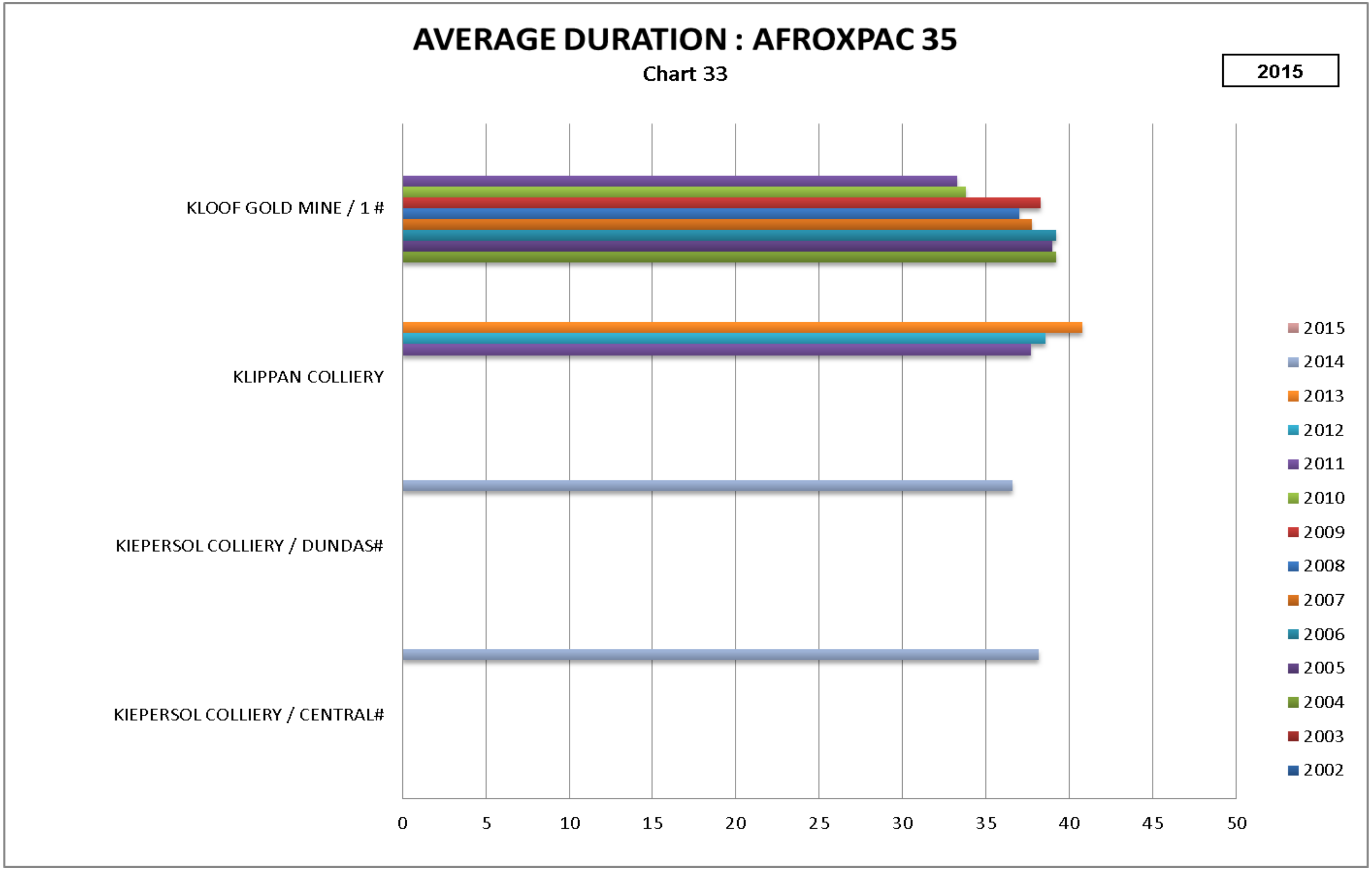

AVERAGE DURATION : AFROXPAC 35
Chart 33
2015
KLOOF GOLD MINE / 1 #
KLIPPAN COLLIERY
KIEPERSOL COLLIERY / DUNDAS#
KIEPERSOL COLLIERY / CENTRAL#
0
5
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2011
2010
2009
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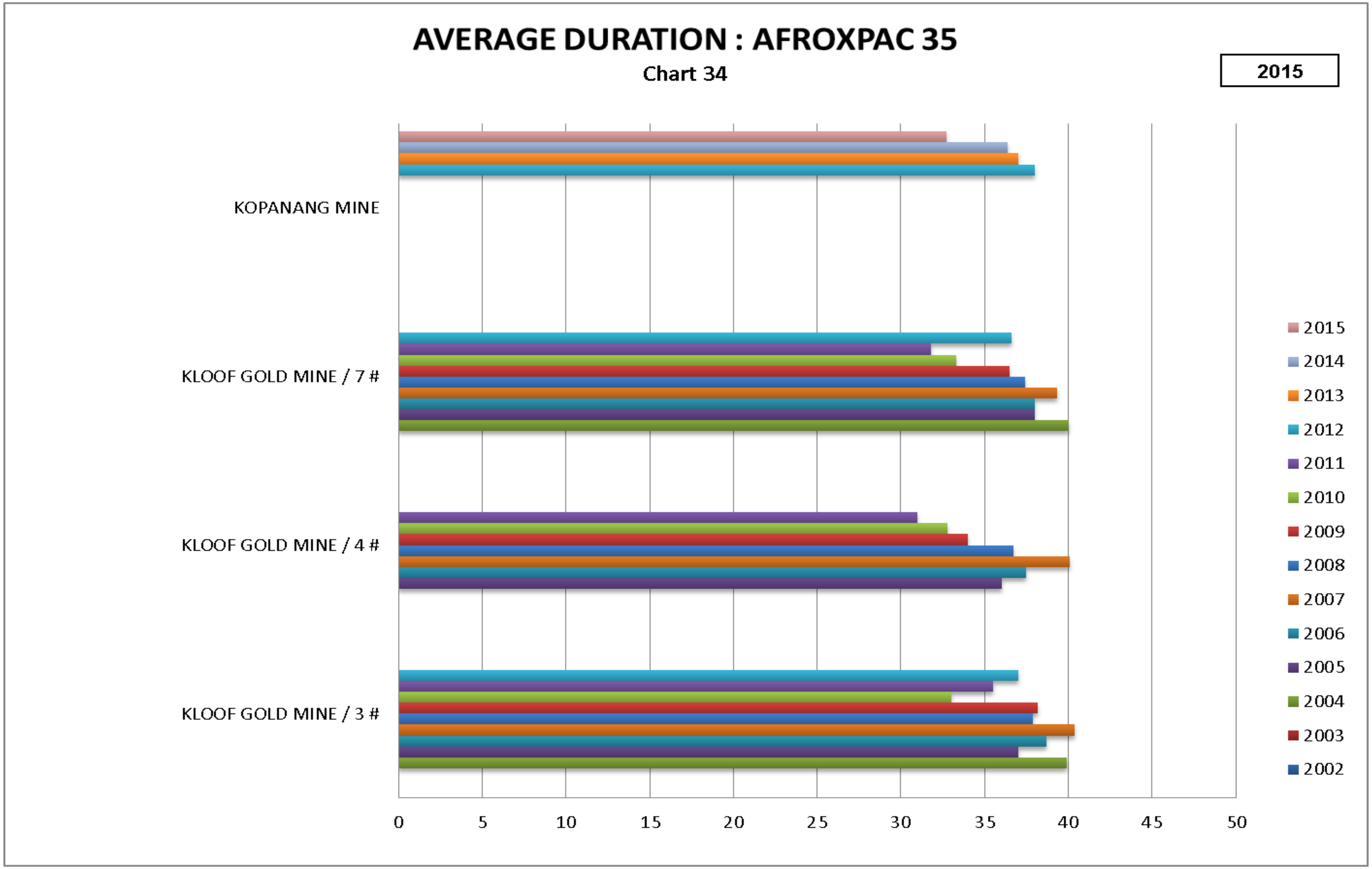
AVERAGE DURATION : AFROXPAC 35
Chart 34
2015
KOPANANG MINE
KLOOF GOLD MINE / 7 #
KLOOF GOLD MINE / 4 #
KLOOF GOLD MINE / 3 #
0
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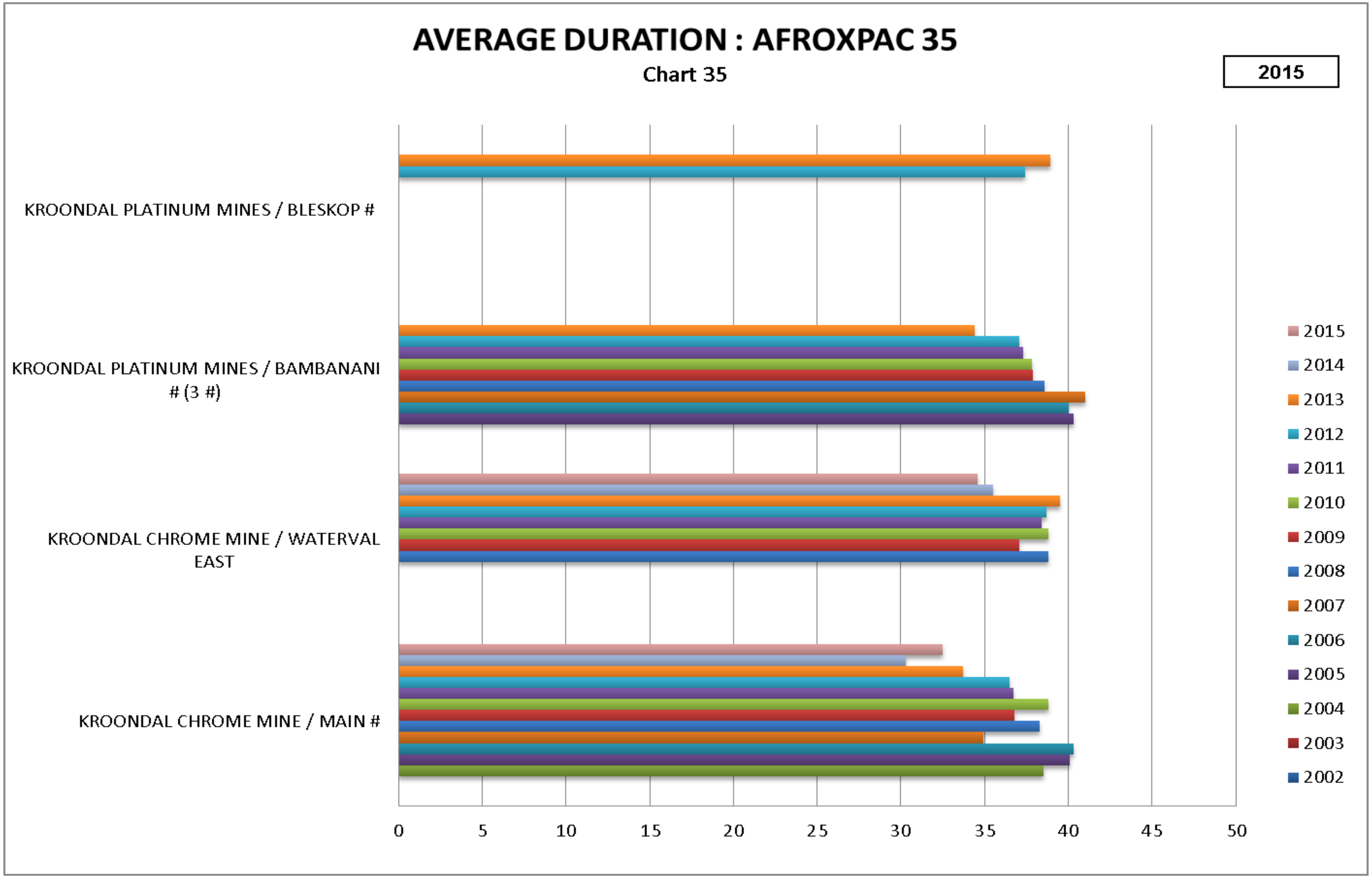
AVERAGE DURATION : AFROXPAC 35
Chart 35
2015
KROONDAL PLATINUM MINES / BLESKOP #
KROONDAL PLATINUM MINES / BAMBANANI # (3 #)
KROONDAL CHROME MINE / WATERVAL EAST
KROONDAL CHROME MINE / MAIN #
0
5
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45
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2015
2014
2013
2012
2011
2010
2009
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2007
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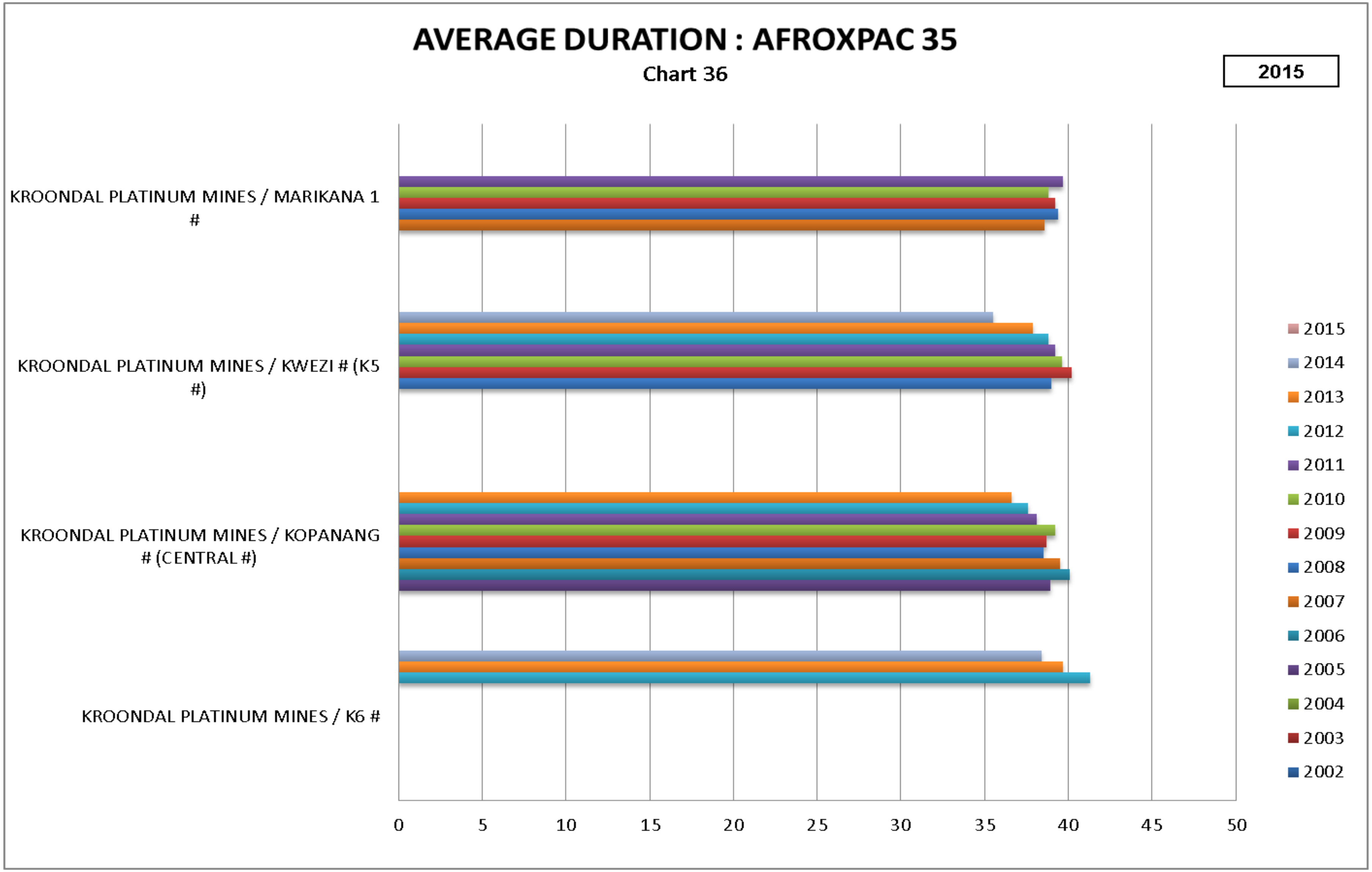
AVERAGE DURATION : AFROXPAC 35
Chart 36
2015
KROONDAL PLATINUM MINES / MARIKANA 1 #
KROONDAL PLATINUM MINES / KWEZI # (K5 #)
KROONDAL PLATINUM MINES / KOPANANG # (CENTRAL #)
KROONDAL PLATINUM MINES / K6 #
0
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2015
2014
2013
2012
2011
2010
2009
2008
2007
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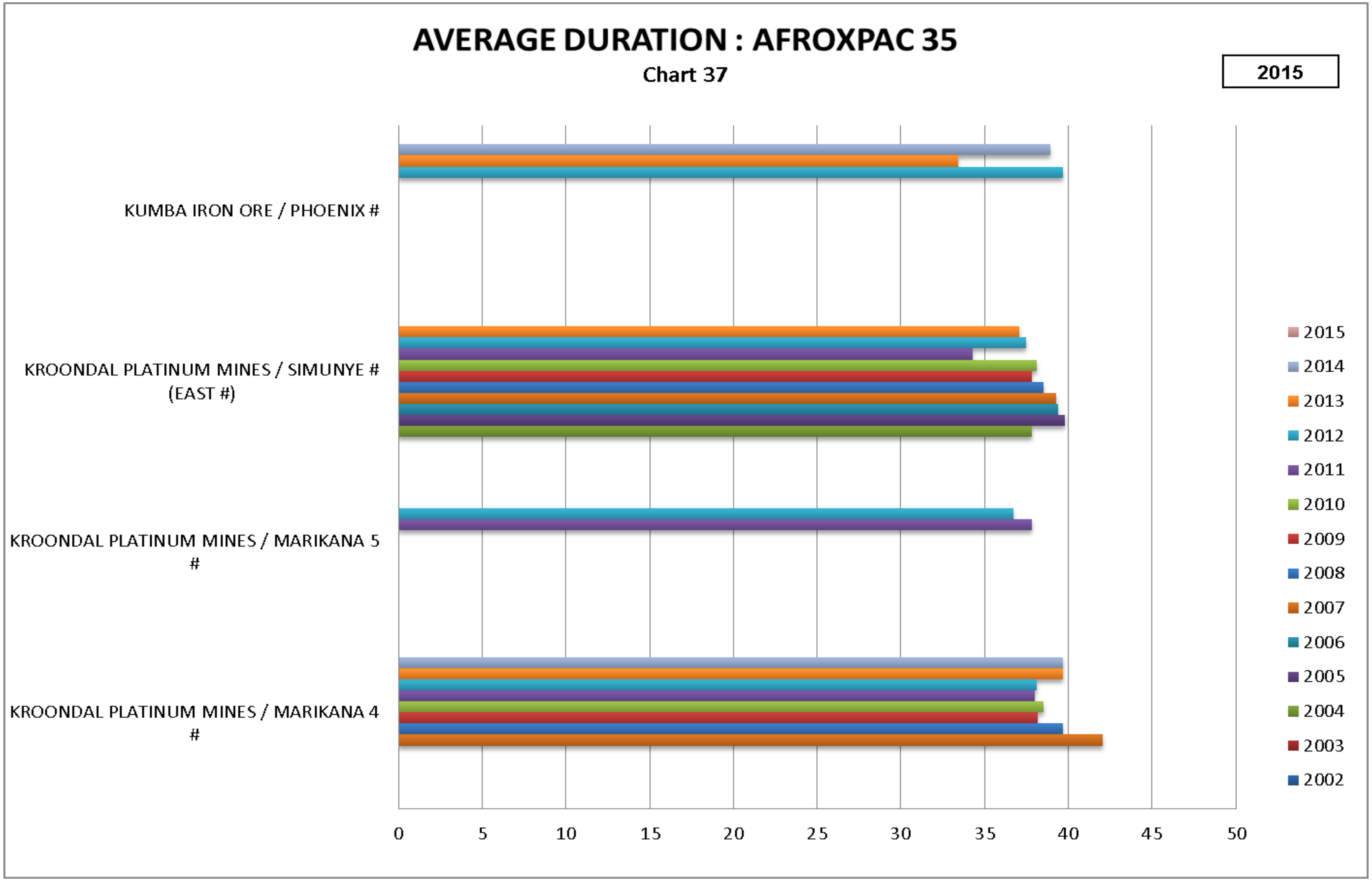

AVERAGE DURATION : AFROXPAC 35
Chart 37
2015
KUMBA IRON ORE / PHOENIX #
KROONDAL PLATINUM MINES / SIMUNYE # (EAST #)
KROONDAL PLATINUM MINES / MARIKANA 5 #
KROONDAL PLATINUM MINES / MARIKANA 4 #
0
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2014
2013
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2011
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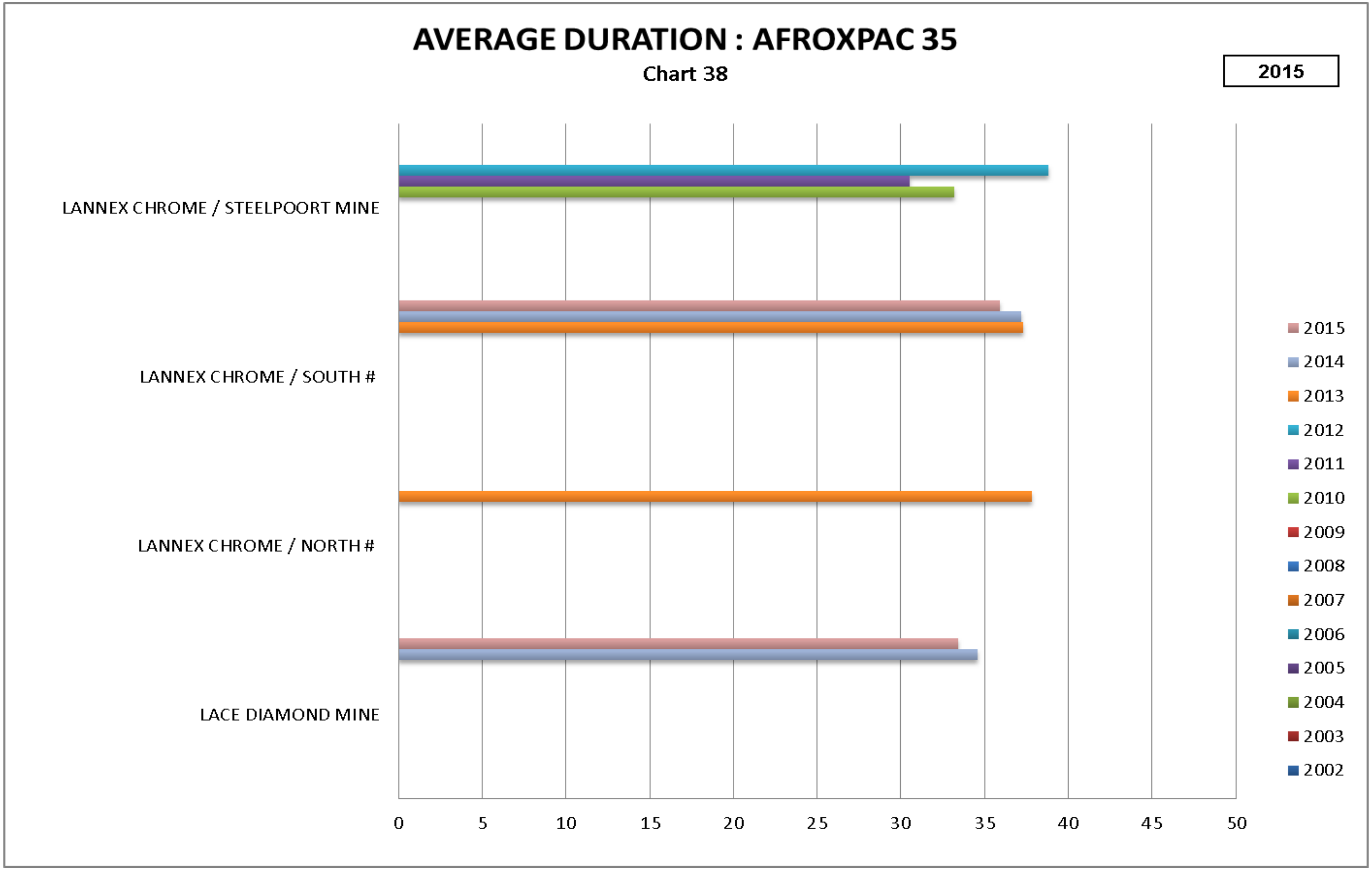
AVERAGE DURATION : AFROXPAC 35
Chart 38
2015
LANNEX CHROME / STEELPOORT MINE
LANNEX CHROME / SOUTH #
LANNEX CHROME / NORTH #
LACE DIAMOND MINE
0
5
10
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2015
2014
2013
2012
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2010
2009
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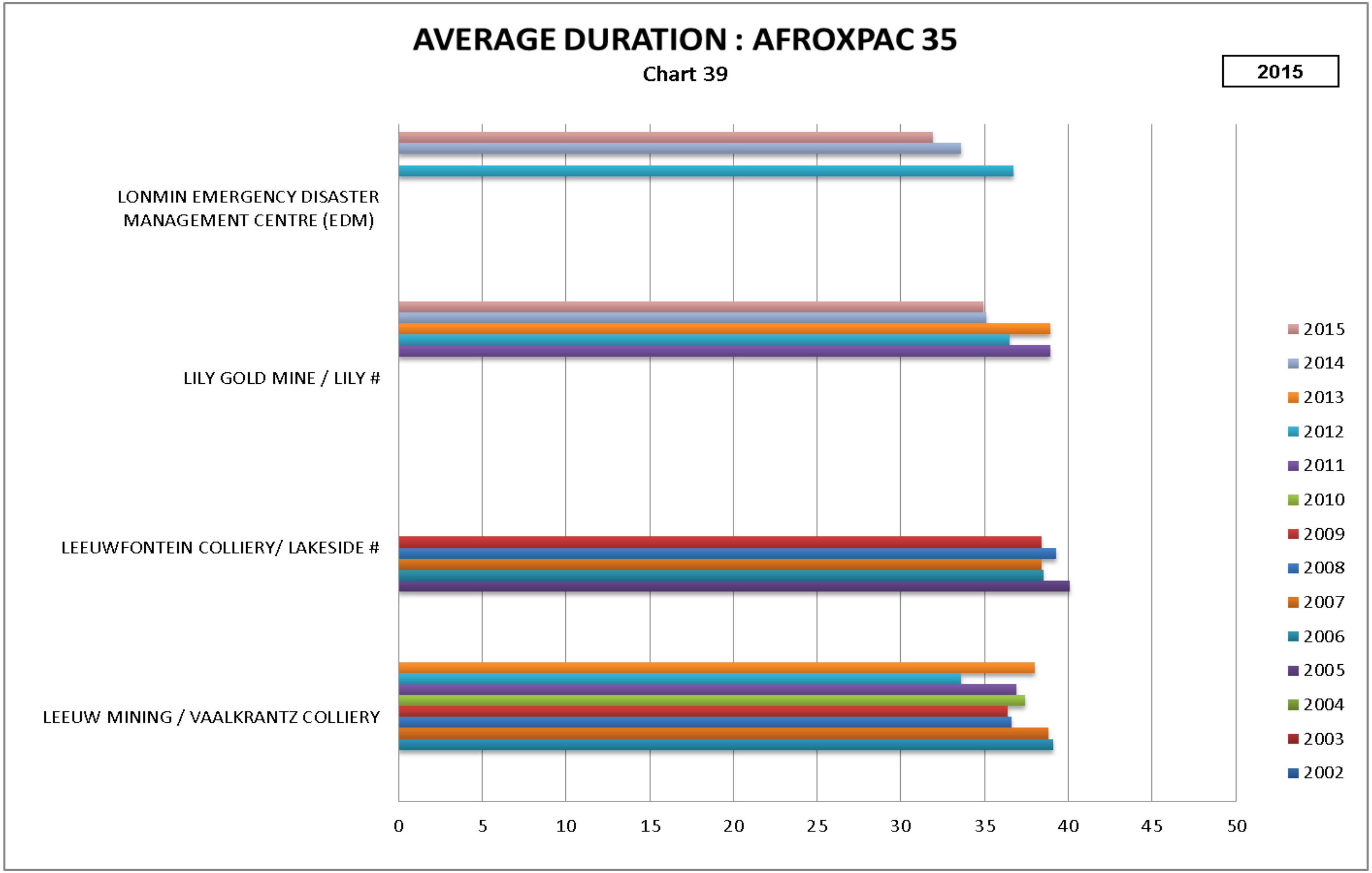
AVERAGE DURATION : AFROXPAC 35
Chart 39
2015
LONMIN EMERGENCY DISASTER MANAGEMENT CENTRE (EDM)
LILY GOLD MINE / LILY #
LEEUWFONTEIN COLLIERY/ LAKESIDE #
LEEUW MINING / VAALKRANTZ COLLIERY
0
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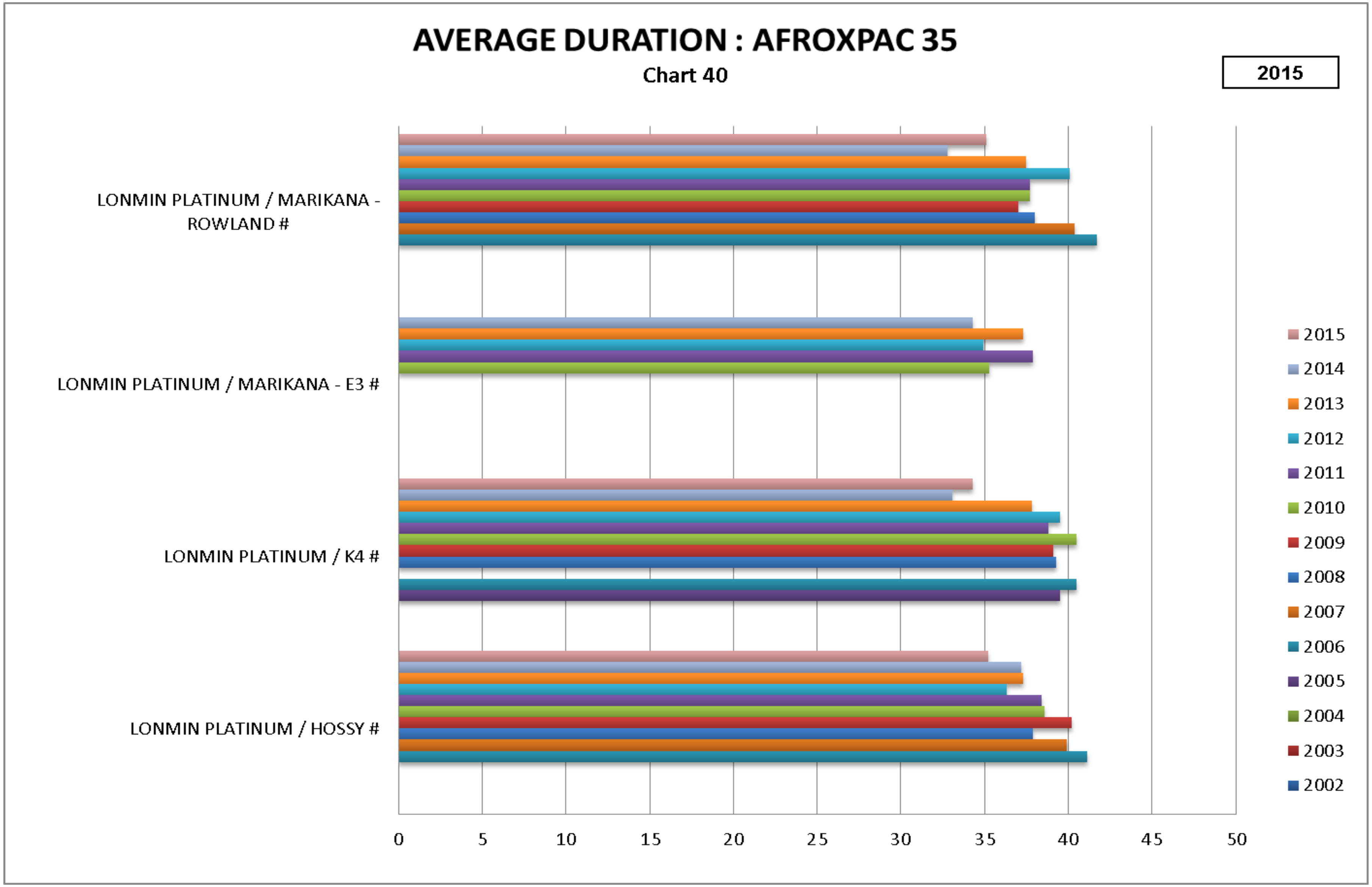

AVERAGE DURATION : AFROXPAC 35
Chart 40
2015
LONMIN PLATINUM / MARIKANA - ROWLAND #
LONMIN PLATINUM / MARIKANA - E3 #
LONMIN PLATINUM / K4 #
LONMIN PLATINUM / HOSSY #
0
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2015
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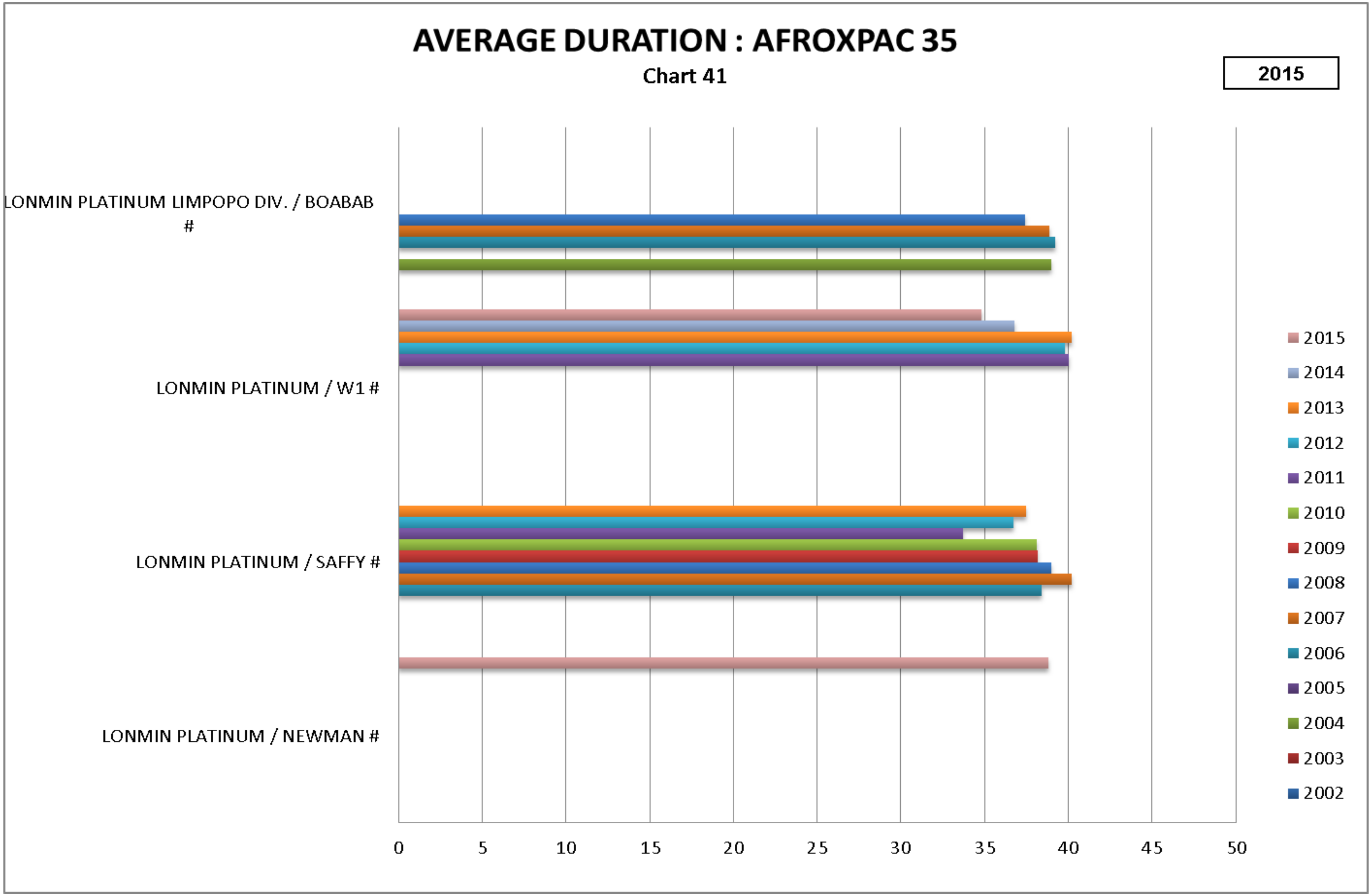
2003
2002



AVERAGE DURATION : AFROXPAC 35
Chart 41
2015
LONMIN PLATINUM LIMPOPO DIV. / BOABAB #
LONMIN PLATINUM / W1 #
LONMIN PLATINUM / SAFFY #
LONMIN PLATINUM / NEWMAN #
0
5
10
15
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30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
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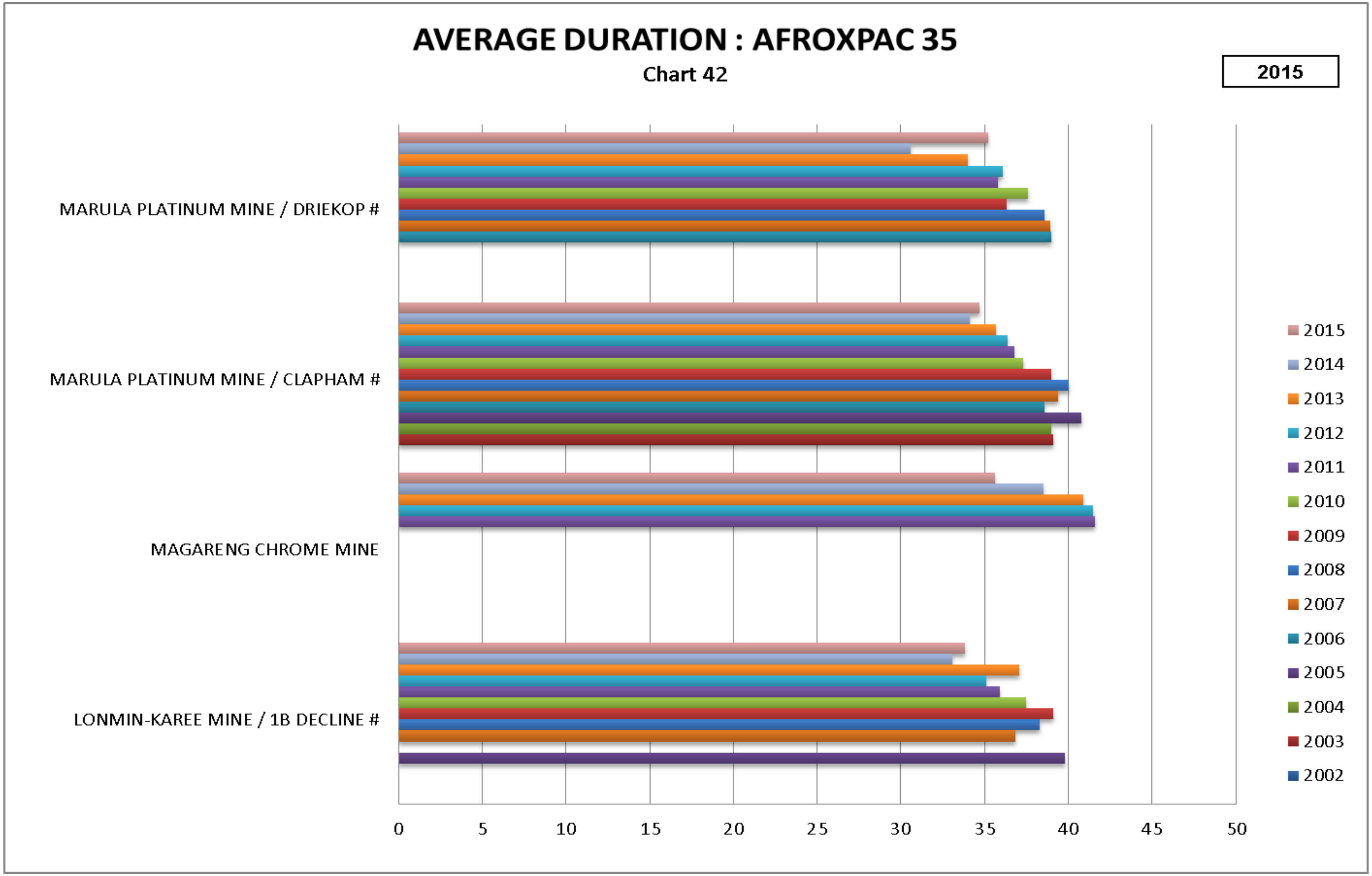

AVERAGE DURATION : AFROXPAC 35
Chart 42
2015
MARULA PLATINUM MINE / DRIEKOP #
MARULA PLATINUM MINE / CLAPHAM #
MAGARENG CHROME MINE
LONMIN-KAREE MINE / 1B DECLINE #
0
5
10
15
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45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
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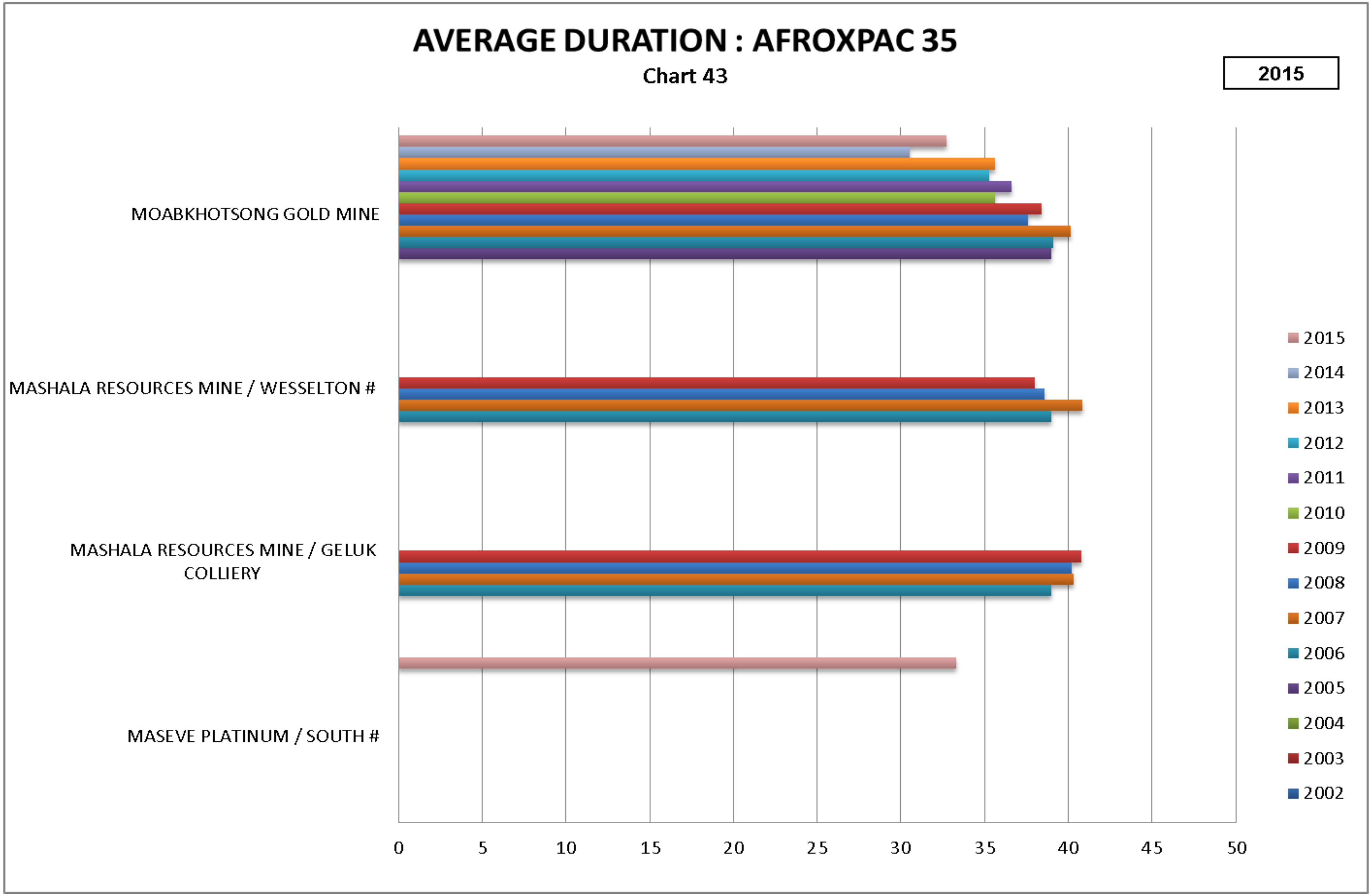
2002



AVERAGE DURATION : AFROXPAC 35
Chart 43
2015
MOABKHOTSONG GOLD MINE
MASHALA RESOURCES MINE / WESSELTON #
MASHALA RESOURCES MINE / GELUK COLLIERY
MASEVE PLATINUM / SOUTH #
0
5
10
15
20
25
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2015
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2009
2008
2007
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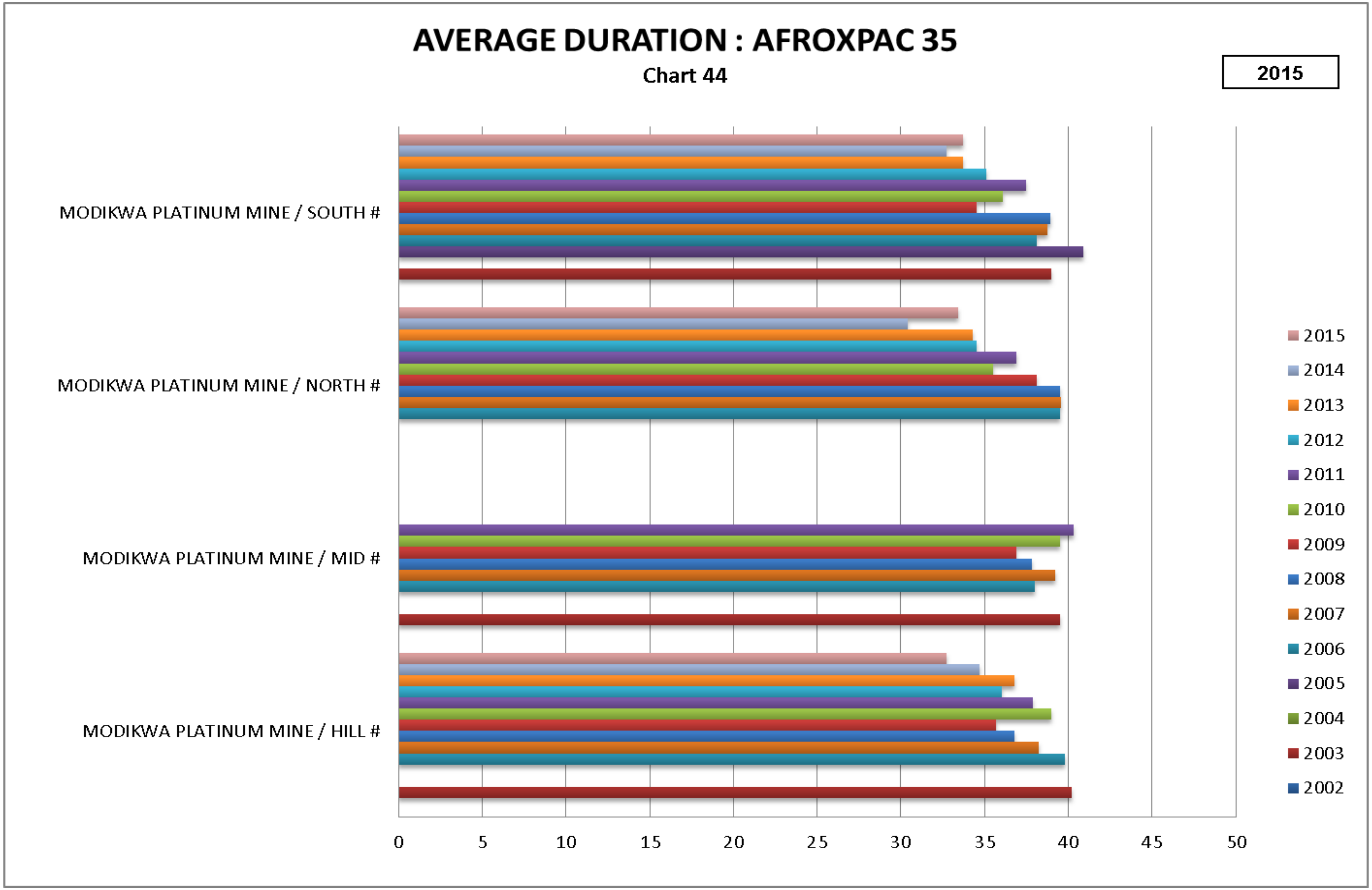
2003
2002


AVERAGE DURATION : AFROXPAC 35
Chart 44
2015
MODIKWA PLATINUM MINE / SOUTH #
MODIKWA PLATINUM MINE / NORTH #
MODIKWA PLATINUM MINE / MID #
MODIKWA PLATINUM MINE / HILL #
0
5
10
15
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25
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2015
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2011
2010
2009
2008
2007
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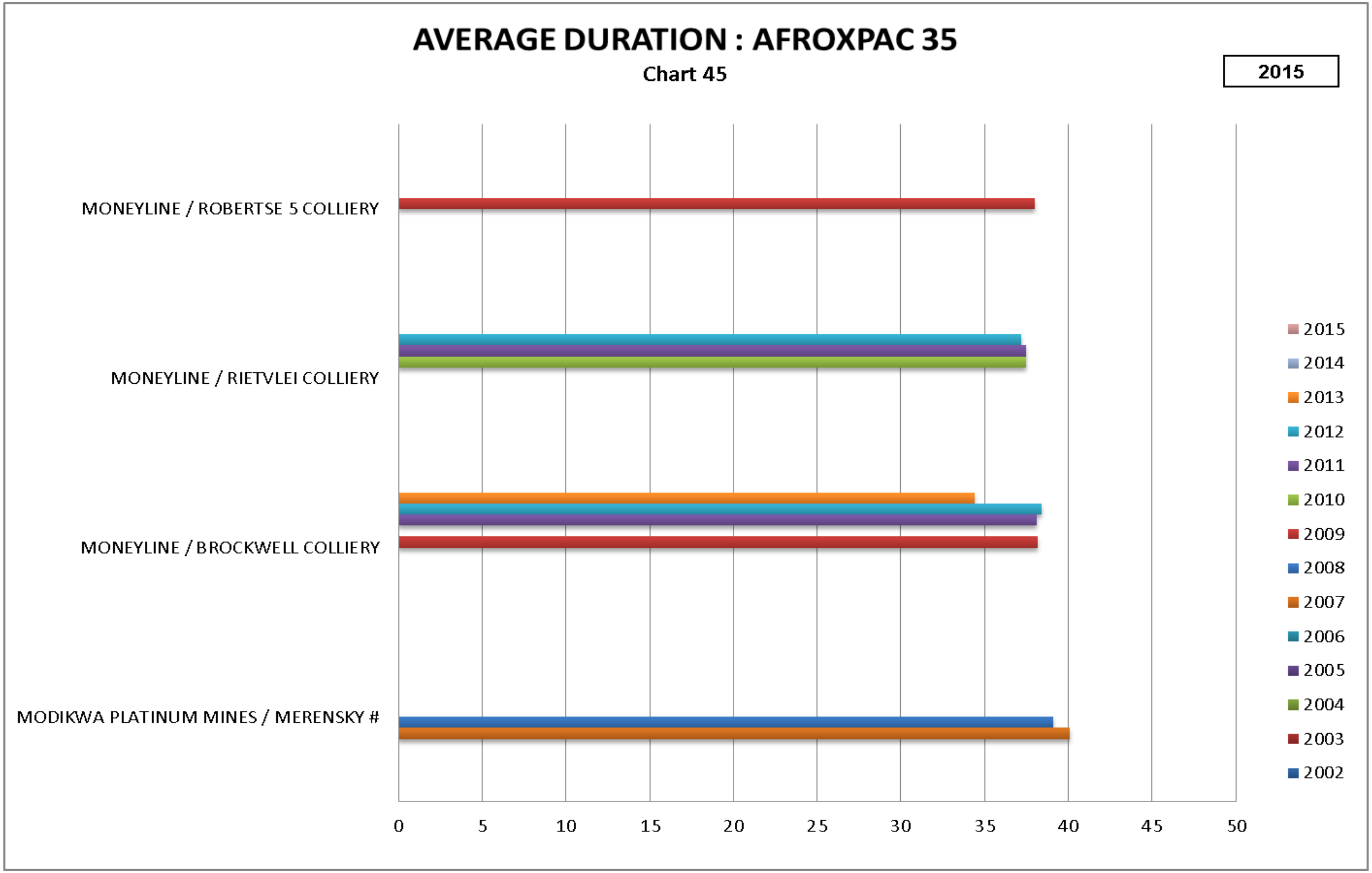

AVERAGE DURATION : AFROXPAC 35
Chart 45
2015
MONEYLINE / ROBERTSE 5 COLLIERY
MONEYLINE / RIETVLEI COLLIERY
MONEYLINE / BROCKWELL COLLIERY
MODIKWA PLATINUM MINES / MERENSKY #
0
5
10
15
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25
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2015
2014
2013
2012
2011
2010
2009
2008
2007
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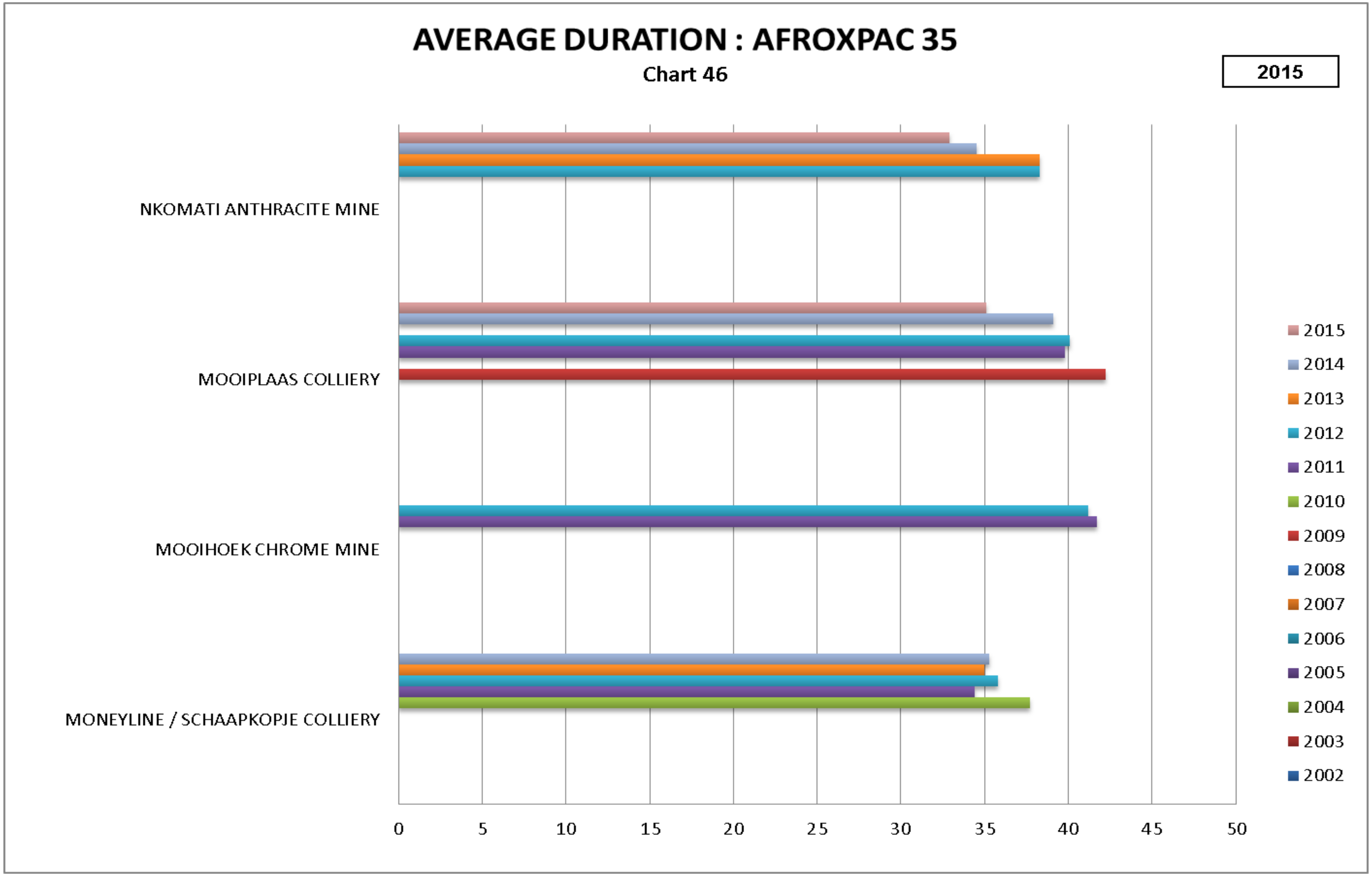

AVERAGE DURATION : AFROXPAC 35
Chart 46
2015
NKOMATI ANTHRACITE MINE
MOOIPLAAS COLLIERY
MOOIHOEK CHROME MINE
MONEYLINE / SCHAAPKOPJE COLLIERY
0
5
10
15
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2015
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2007
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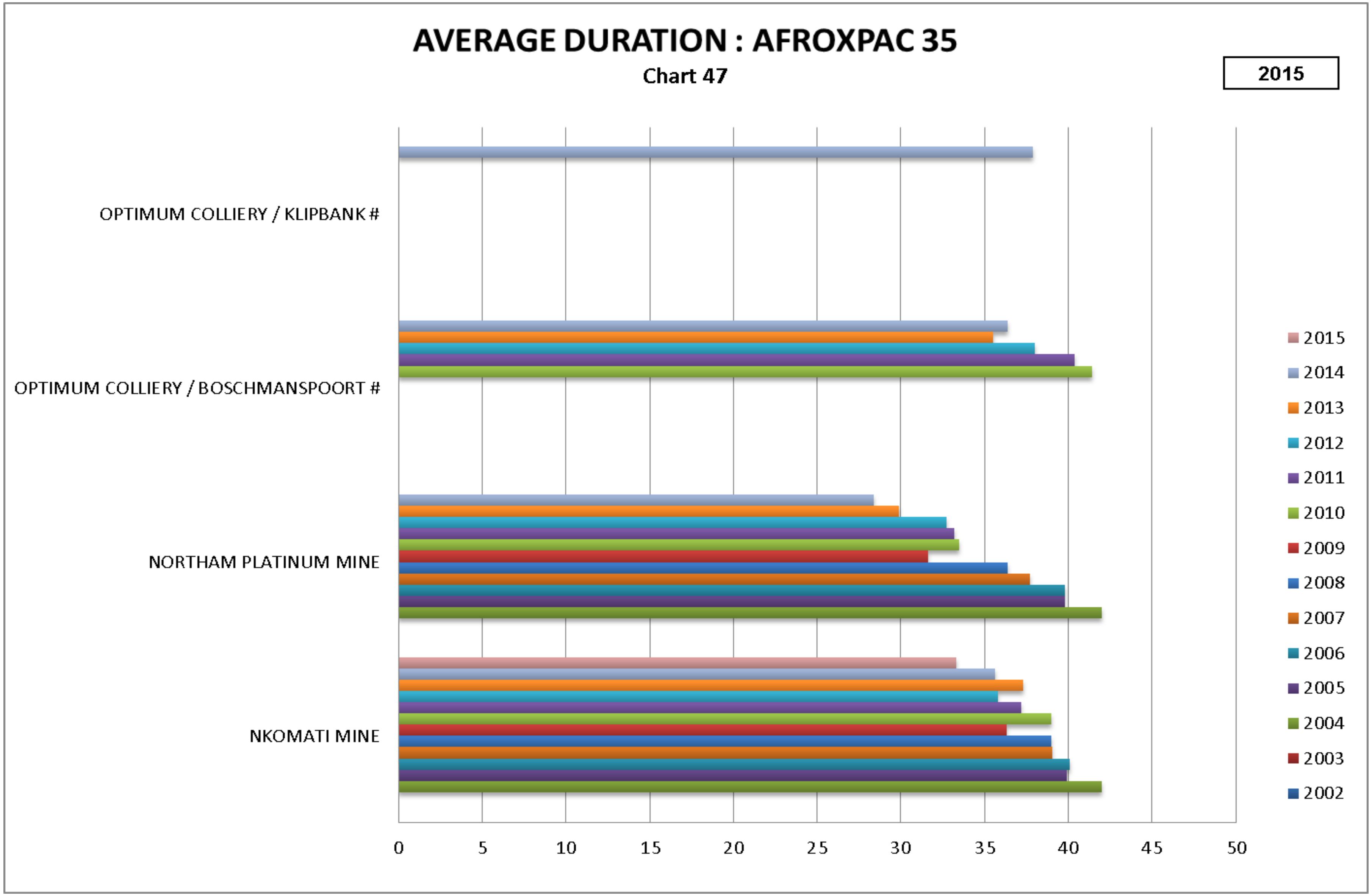
AVERAGE DURATION : AFROXPAC 35
Chart 47
2015
OPTIMUM COLLIERY / KLIPBANK #
OPTIMUM COLLIERY / BOSCHMANSPOORT #
NORTHAM PLATINUM MINE
NKOMATI MINE
0
5
10
15
20
25
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2015
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2007
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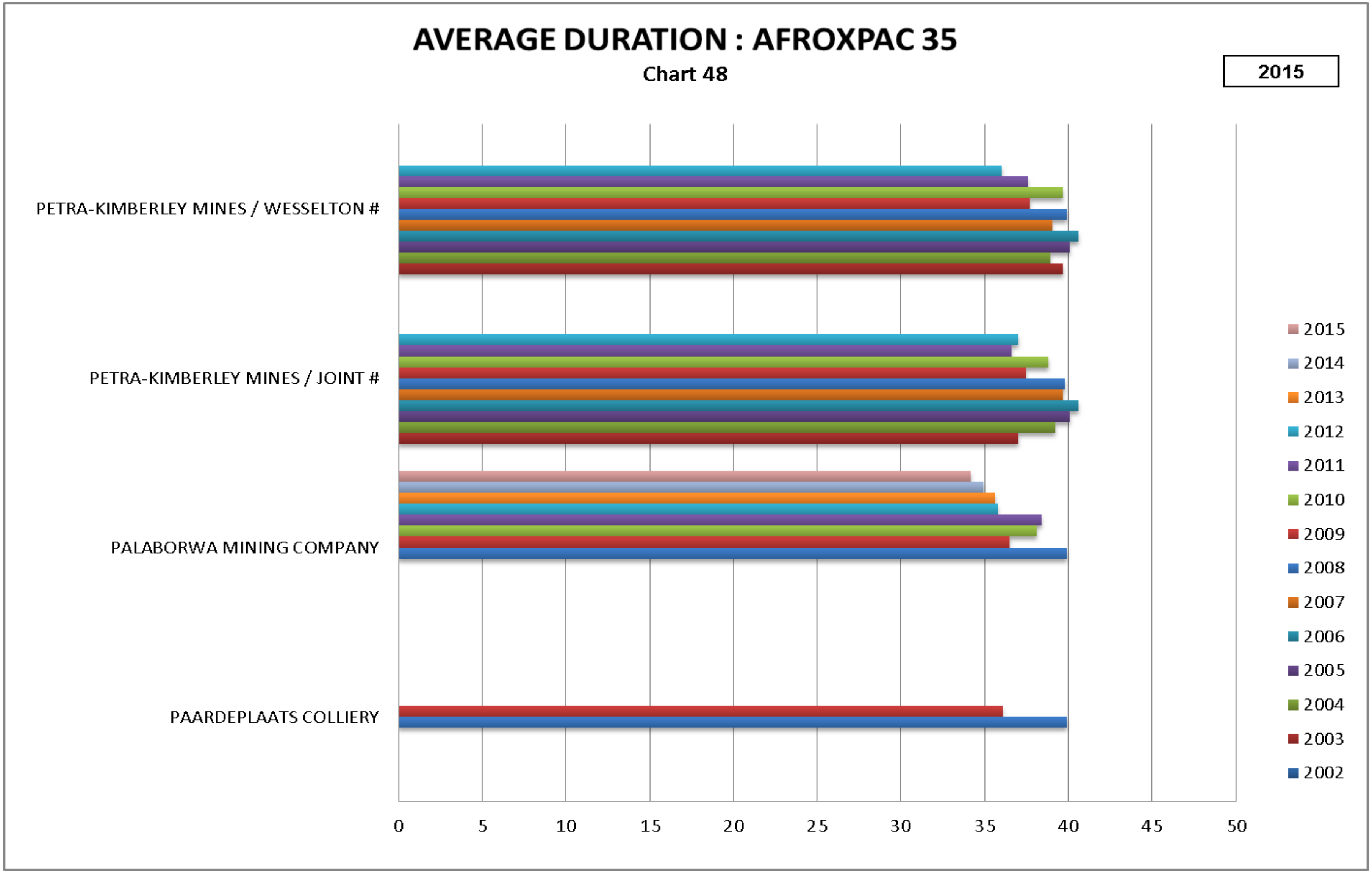

AVERAGE DURATION : AFROXPAC 35
Chart 48
2015
PETRA-KIMBERLEY MINES / WESSELTON #
PETRA-KIMBERLEY MINES / JOINT #
PALABORWA MINING COMPANY
PAARDEPLAATS COLLIERY
0
5
10
15
20
25
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35
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2015
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2008
2007
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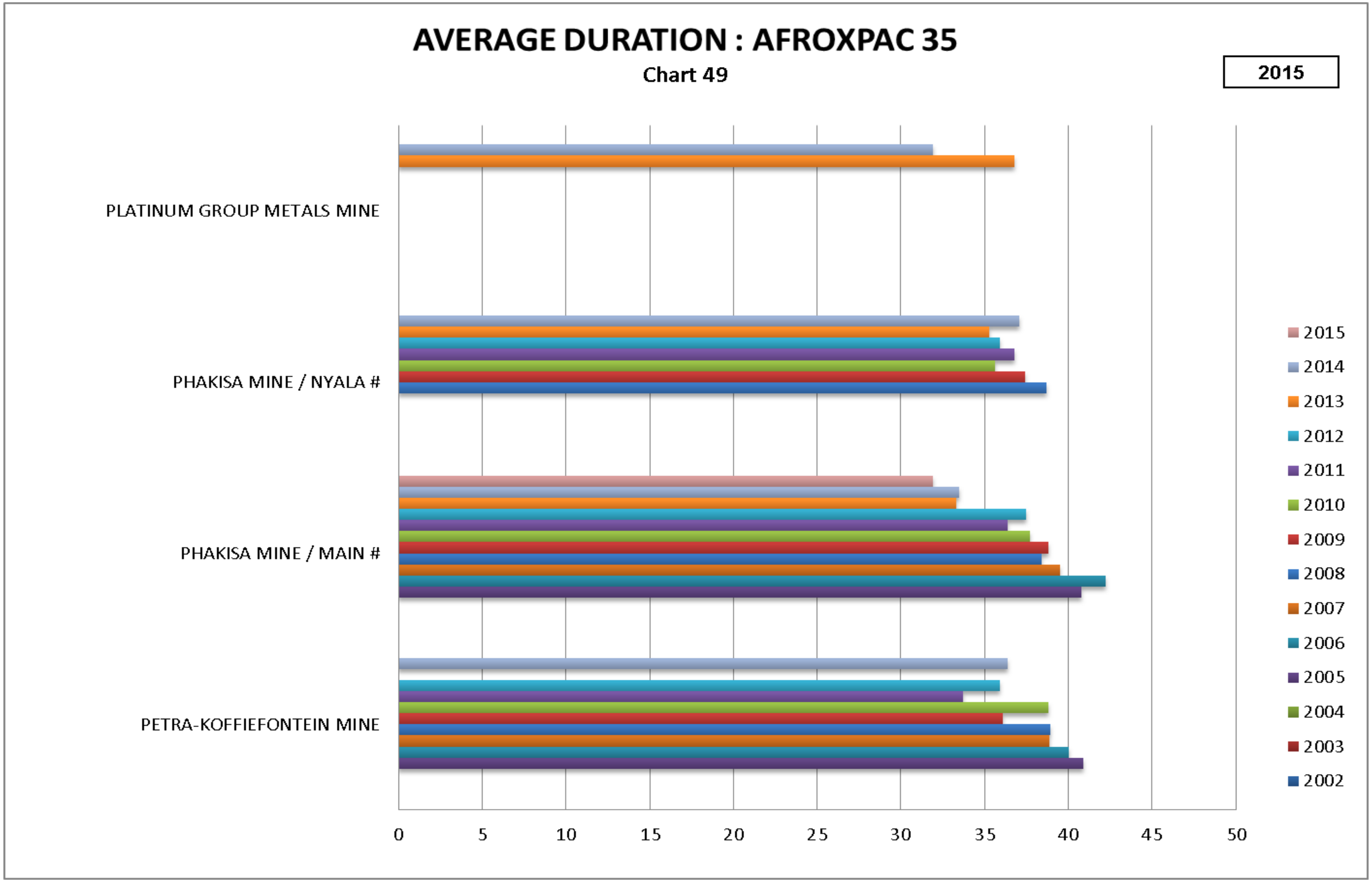
2002


AVERAGE DURATION : AFROXPAC 35
Chart 49
2015
PLATINUM GROUP METALS MINE
PHAKISA MINE / NYALA #
PHAKISA MINE / MAIN #
PETRA-KOFFIEFONTEIN MINE
0
5
10
15
20
25
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35
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45
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2015
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2013
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2010
2009
2008
2007
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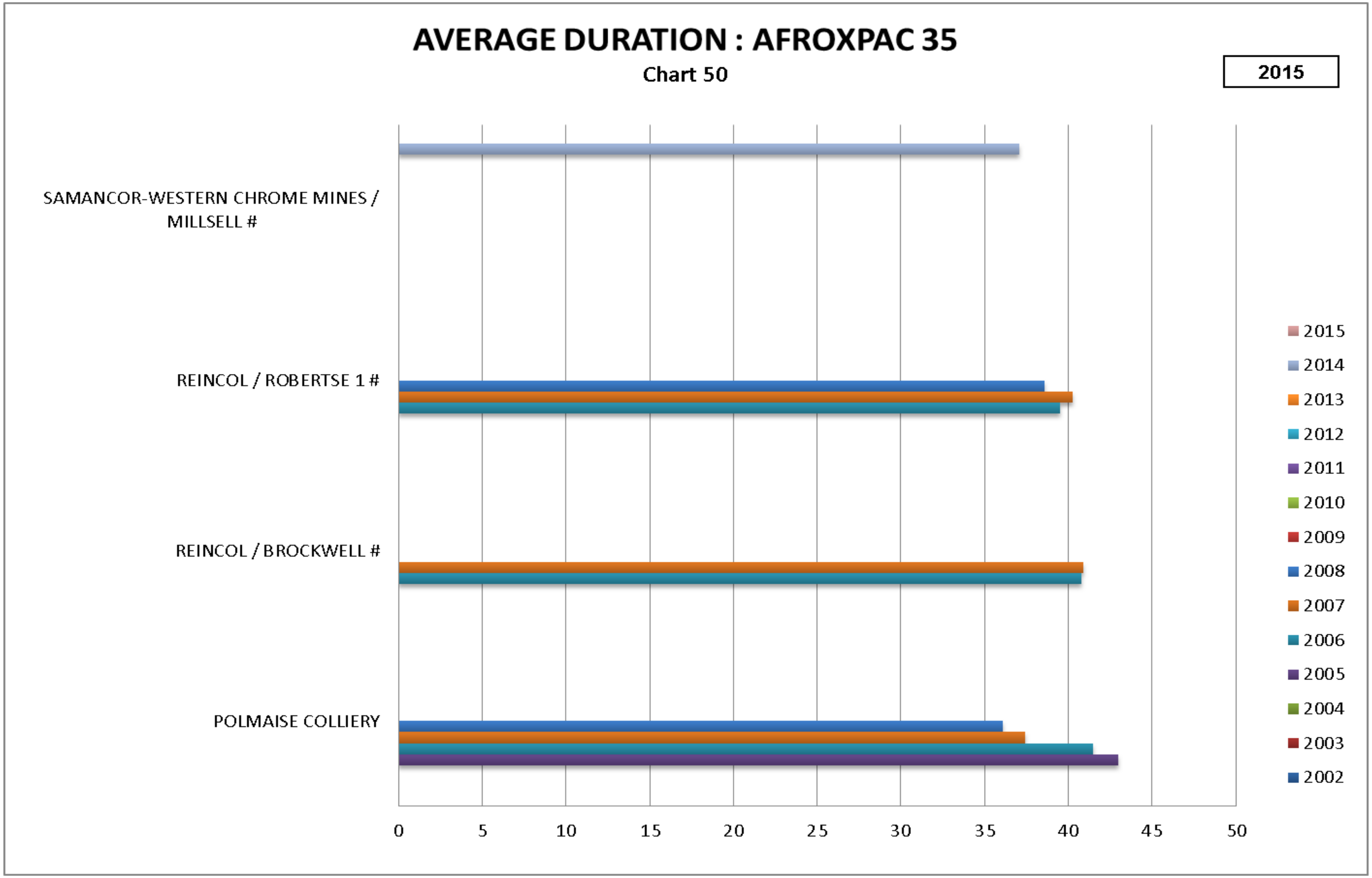
2002


AVERAGE DURATION : AFROXPAC 35
Chart 50
2015
SAMANCOR-WESTERN CHROME MINES / MILLSELL #
REINCOL / ROBERTSE 1 #
REINCOL / BROCKWELL #
POLMAISE COLLIERY
0
5
10
15
20
25
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2015
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2009
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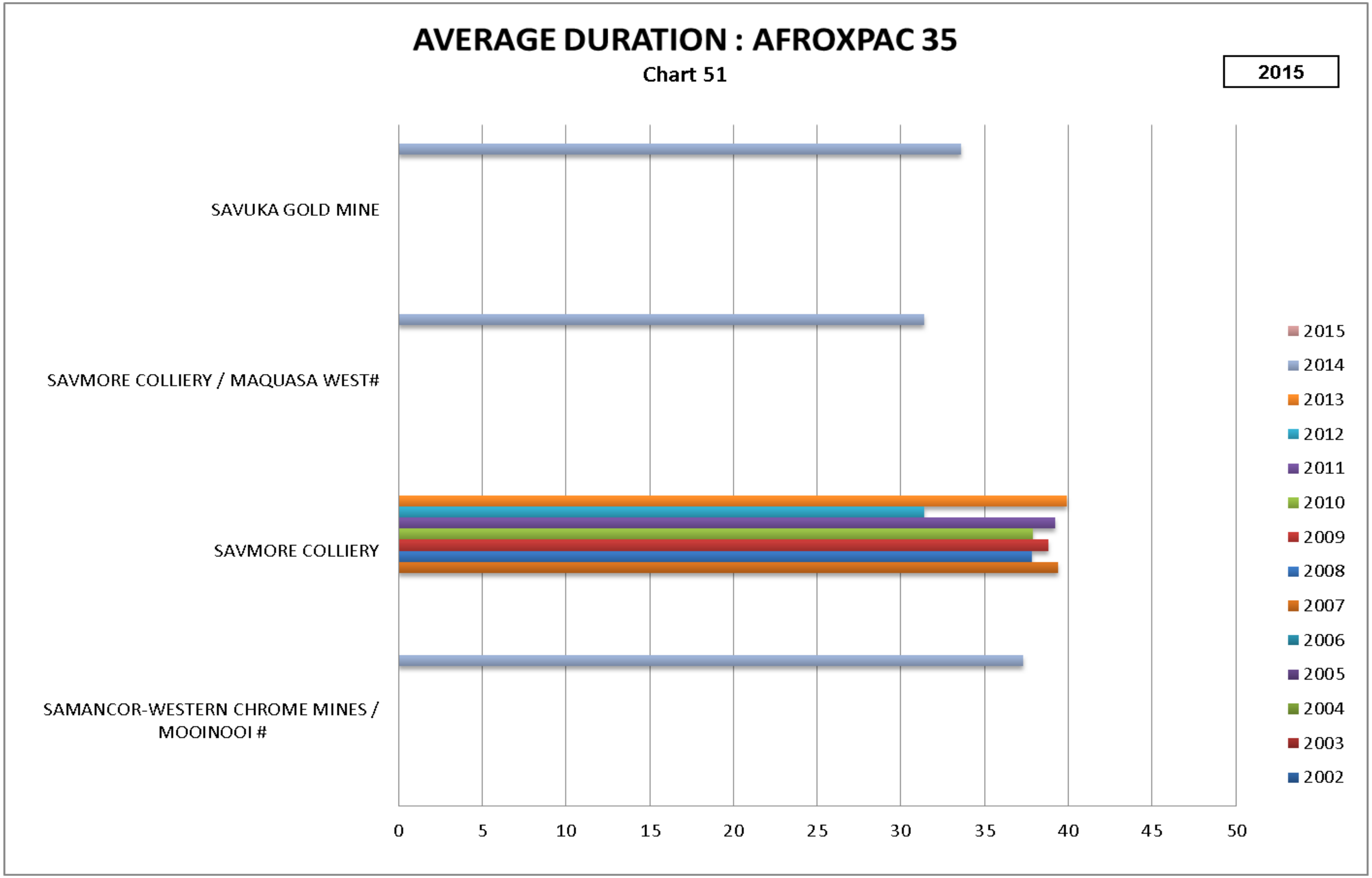
2002


AVERAGE DURATION : AFROXPAC 35
Chart 51
2015
SAVUKA GOLD MINE
SAVMORE COLLIERY / MAQUASA WEST#
SAVMORE COLLIERY
SAMANCOR-WESTERN CHROME MINES / MOOINOOI #
0
5
10
15
20
25
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2015
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2011
2010
2009
2008
2007
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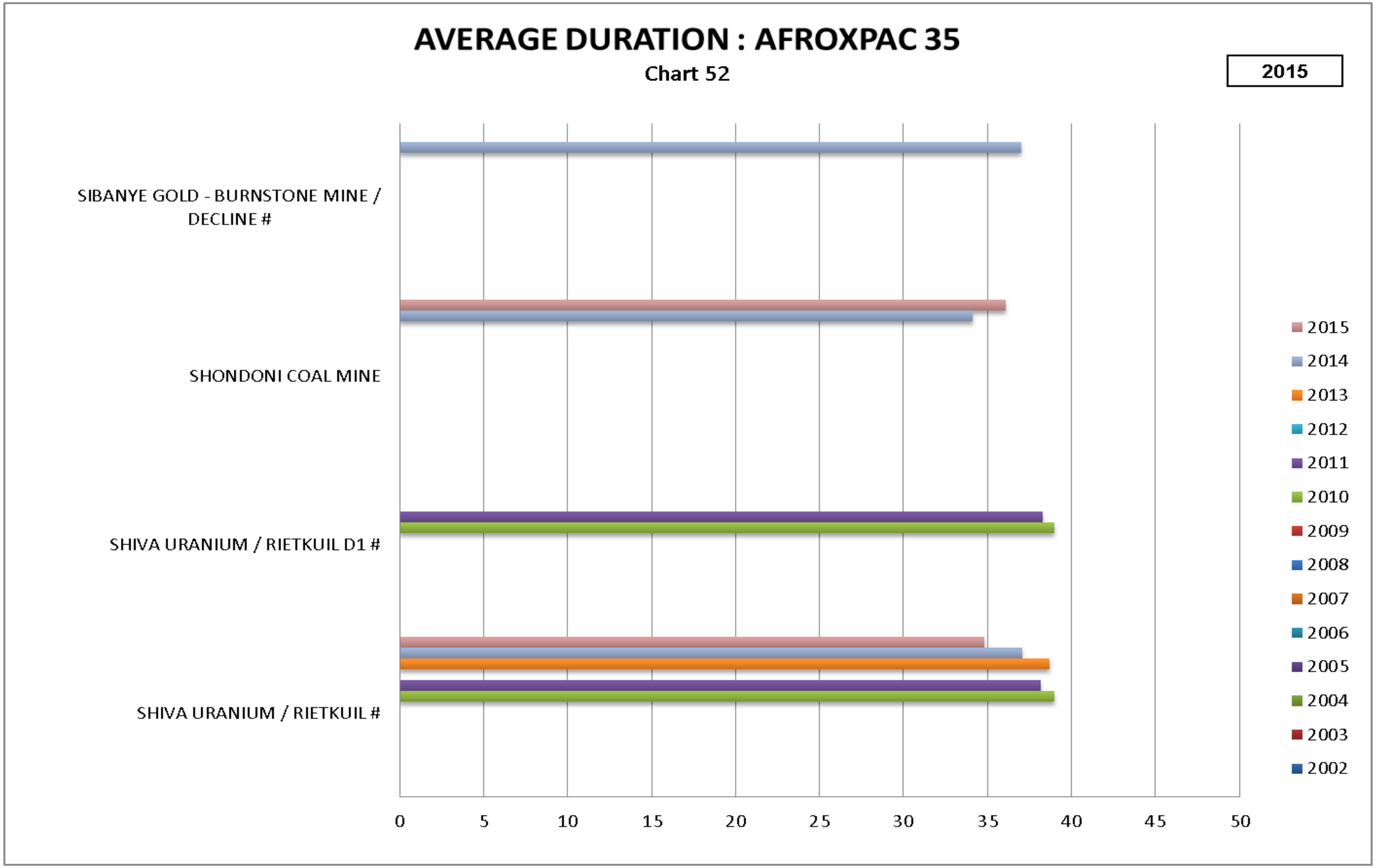
2002


AVERAGE DURATION : AFROXPAC 35
Chart 52
2015
SIBANYE GOLD - BURNSTONE MINE / DECLINE #
SHONDONI COAL MINE
SHIVA URANIUM / RIETKUIL D1 #
SHIVA URANIUM / RIETKUIL #
0
5
10
15
20
25
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2015
2014
2013
2012
2011
2010
2009
2008
2007
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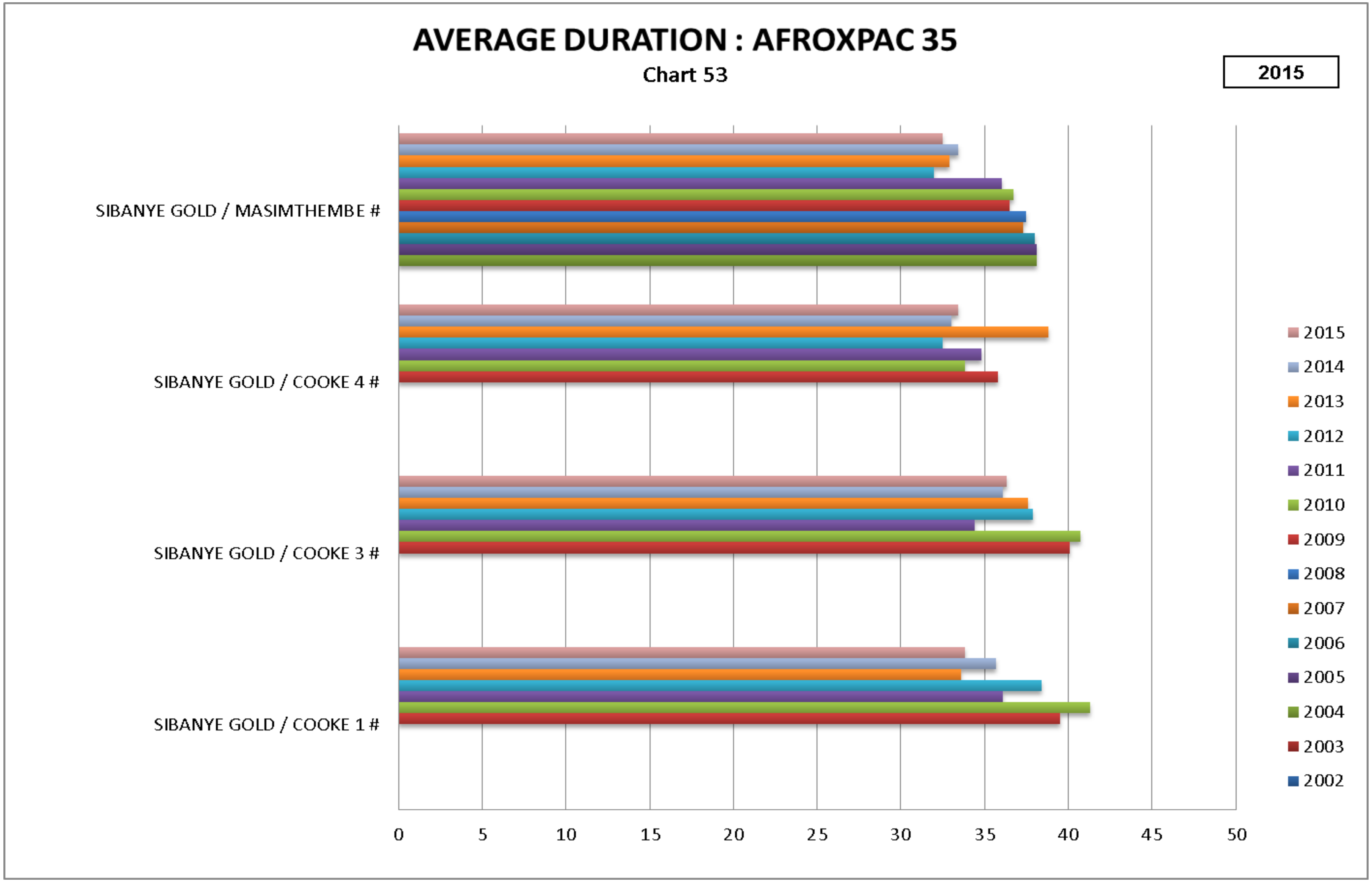
2003
2002


AVERAGE DURATION : AFROXPAC 35
Chart 53
2015
SIBANYE GOLD / MASIMTHEMBE #
SIBANYE GOLD / COOKE 4 #
SIBANYE GOLD / COOKE 3 #
SIBANYE GOLD / COOKE 1 #
0
5
10
15
20
25
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45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
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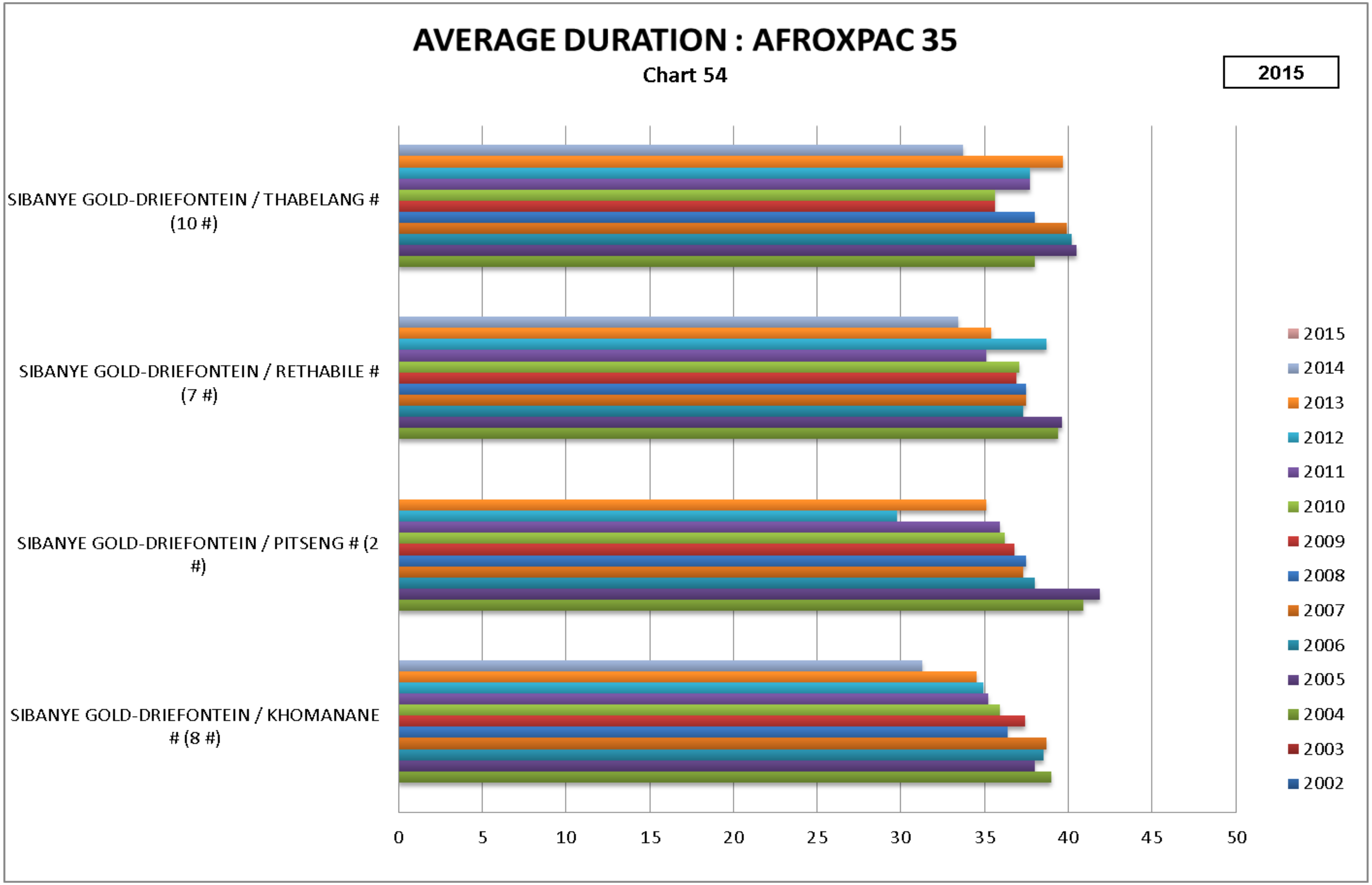
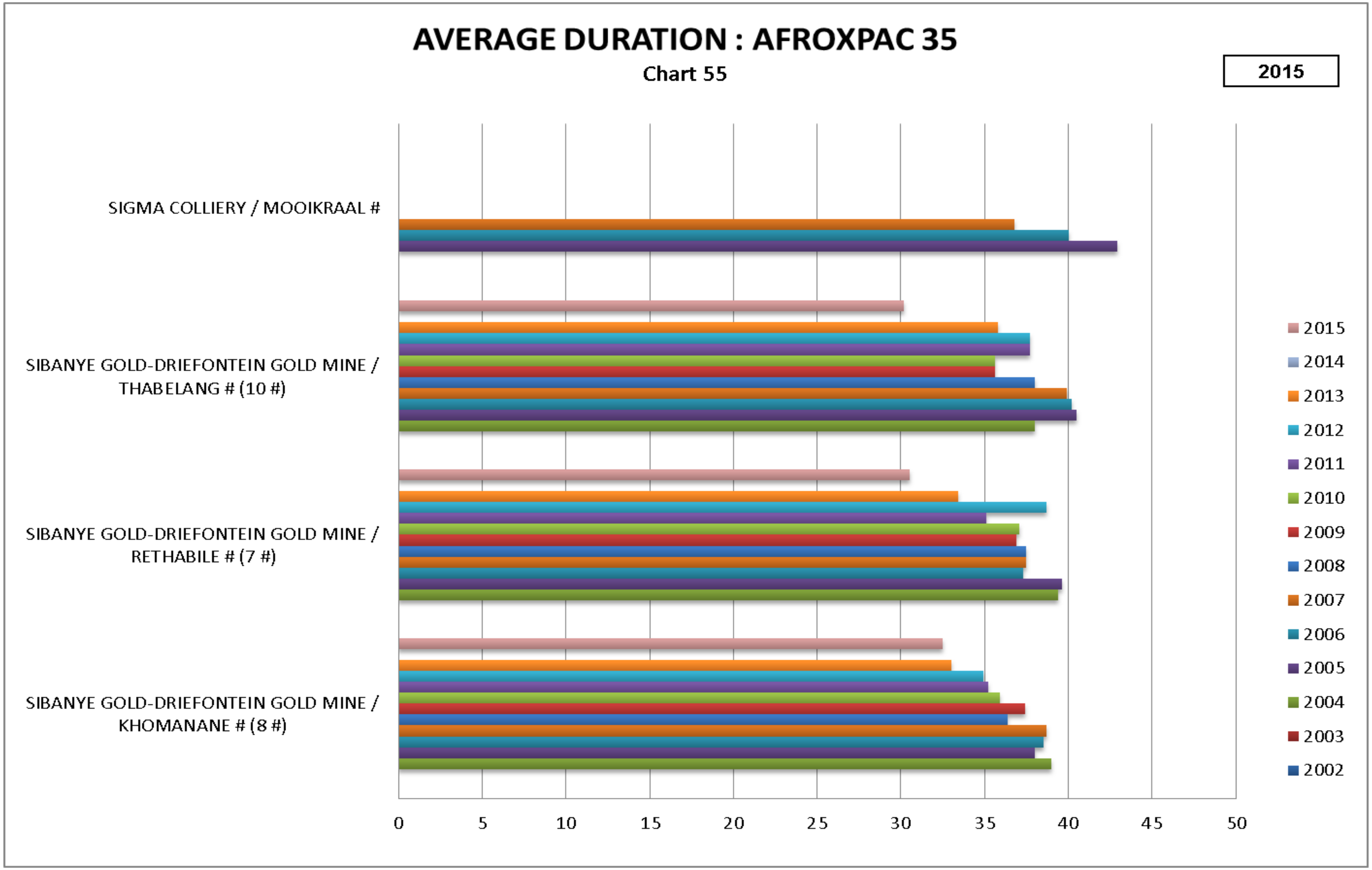
2003
2002


AVERAGE DURATION : AFROXPAC 35
Chart 54
2015
SIBANYE GOLD-DRIEFONTEIN / THABELANG # (10 #)
SIBANYE GOLD-DRIEFONTEIN / RETHABILE # (7 #)
SIBANYE GOLD-DRIEFONTEIN / PITSENG # (2 #)
SIBANYE GOLD-DRIEFONTEIN / KHOMANANE # (8 #)
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002


AVERAGE DURATION : AFROXPAC 35
Chart 55
2015
SIGMA COLLIERY / MOOIKRAAL #
SIBANYE GOLD-DRIEFONTEIN GOLD MINE / THABELANG # (10 #)
SIBANYE GOLD-DRIEFONTEIN GOLD MINE / RETHABILE # (7 #)
SIBANYE GOLD-DRIEFONTEIN GOLD MINE / KHOMANANE # (8 #)
0
5
10
15
20
25
30
35
40
45
50
2015
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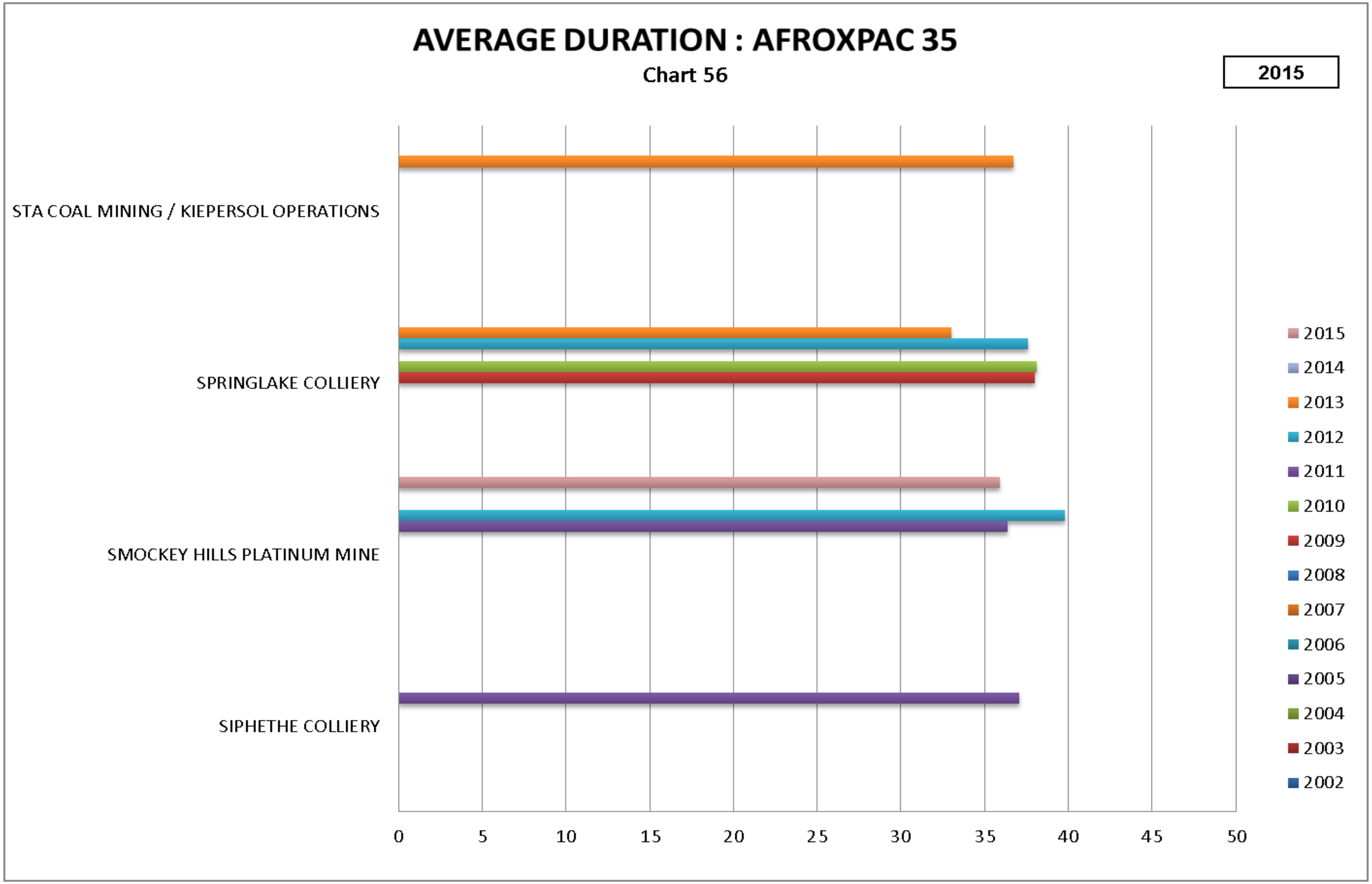
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002


AVERAGE DURATION : AFROXPAC 35
Chart 56
2015
STA COAL MINING / KIEPERSOL OPERATIONS
SPRINGLAKE COLLIERY
SMOCKEY HILLS PLATINUM MINE
SIPHETHE COLLIERY
0
5
10
15
20
25
30
35
40
45
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2015
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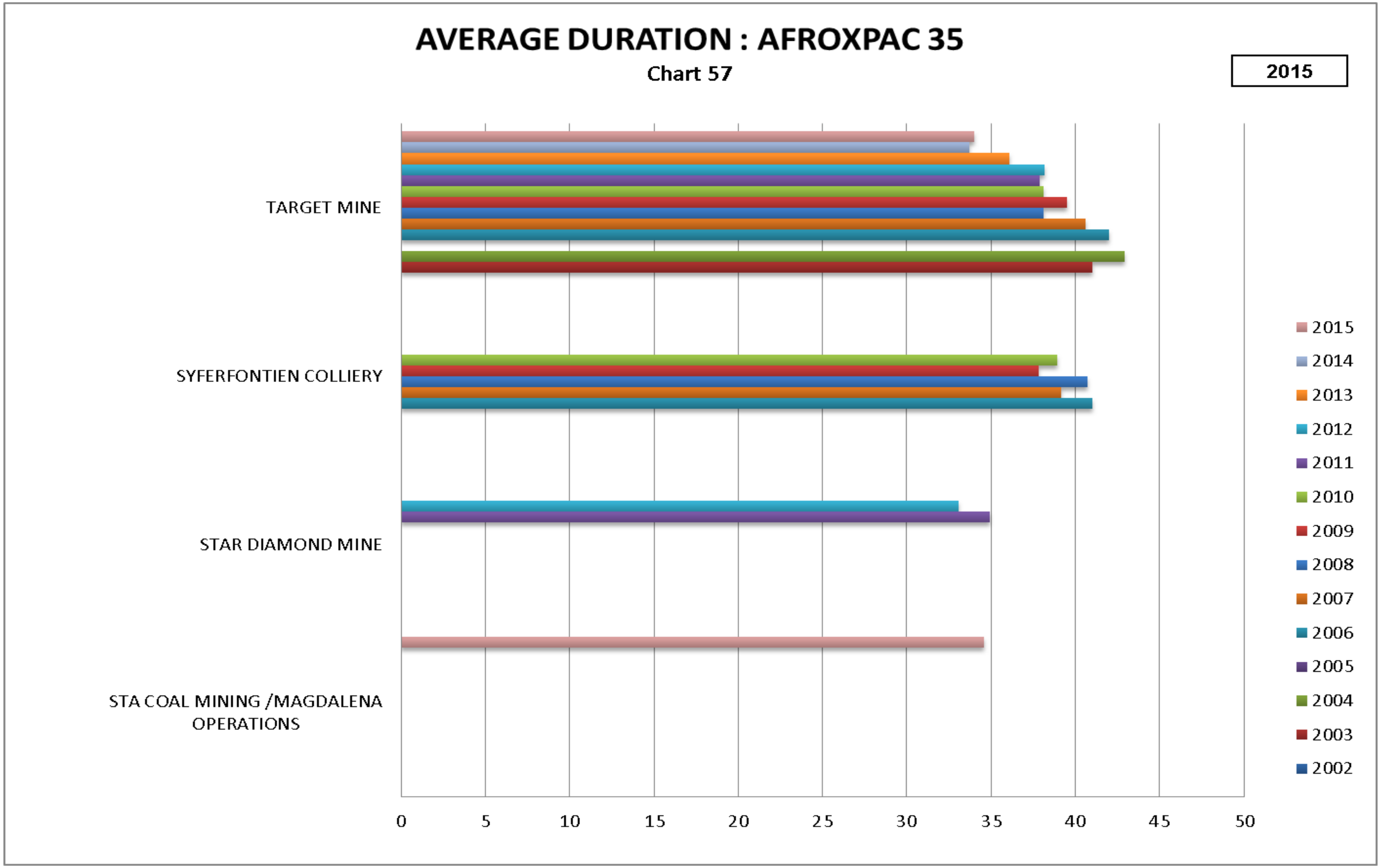
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002



AVERAGE DURATION : AFROXPAC 35
Chart 57
2015
TARGET MINE
SYFERFONTIEN COLLIERY
STAR DIAMOND MINE
STA COAL MINING /MAGDALENA OPERATIONS
0
5
10
15
20
25
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35
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45
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2015
2014
2013
2012
2011
2010
2009
2008
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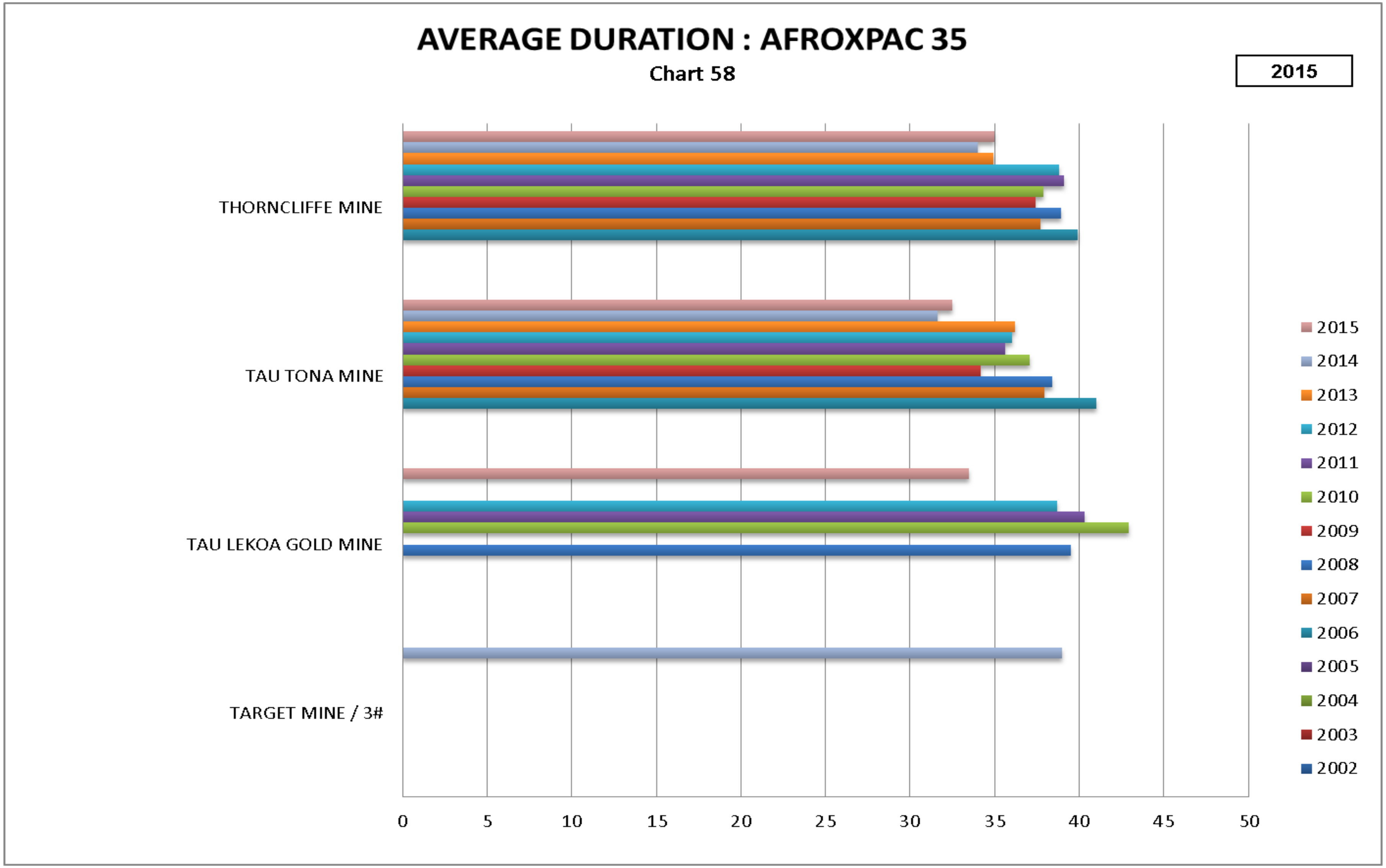
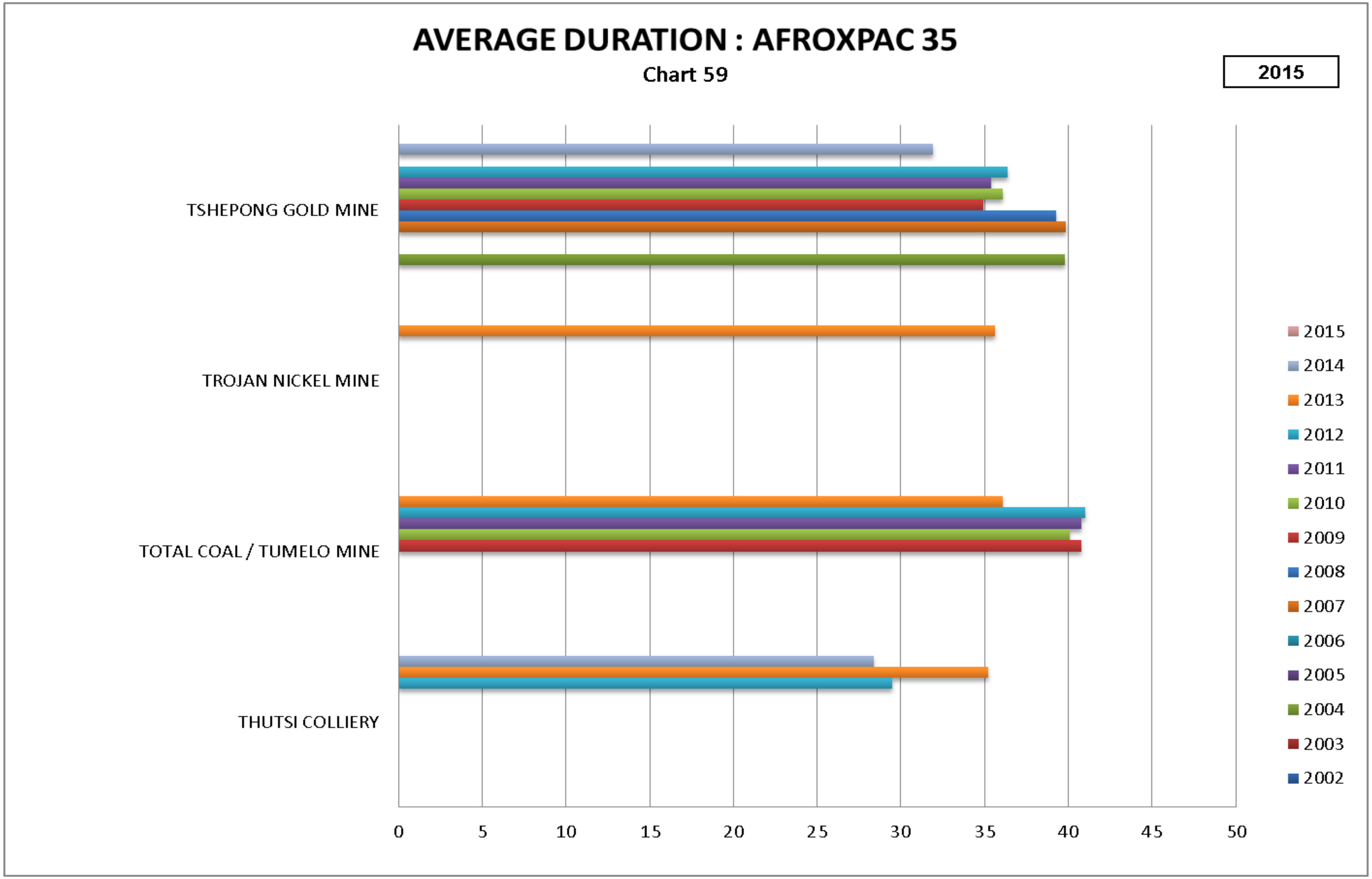
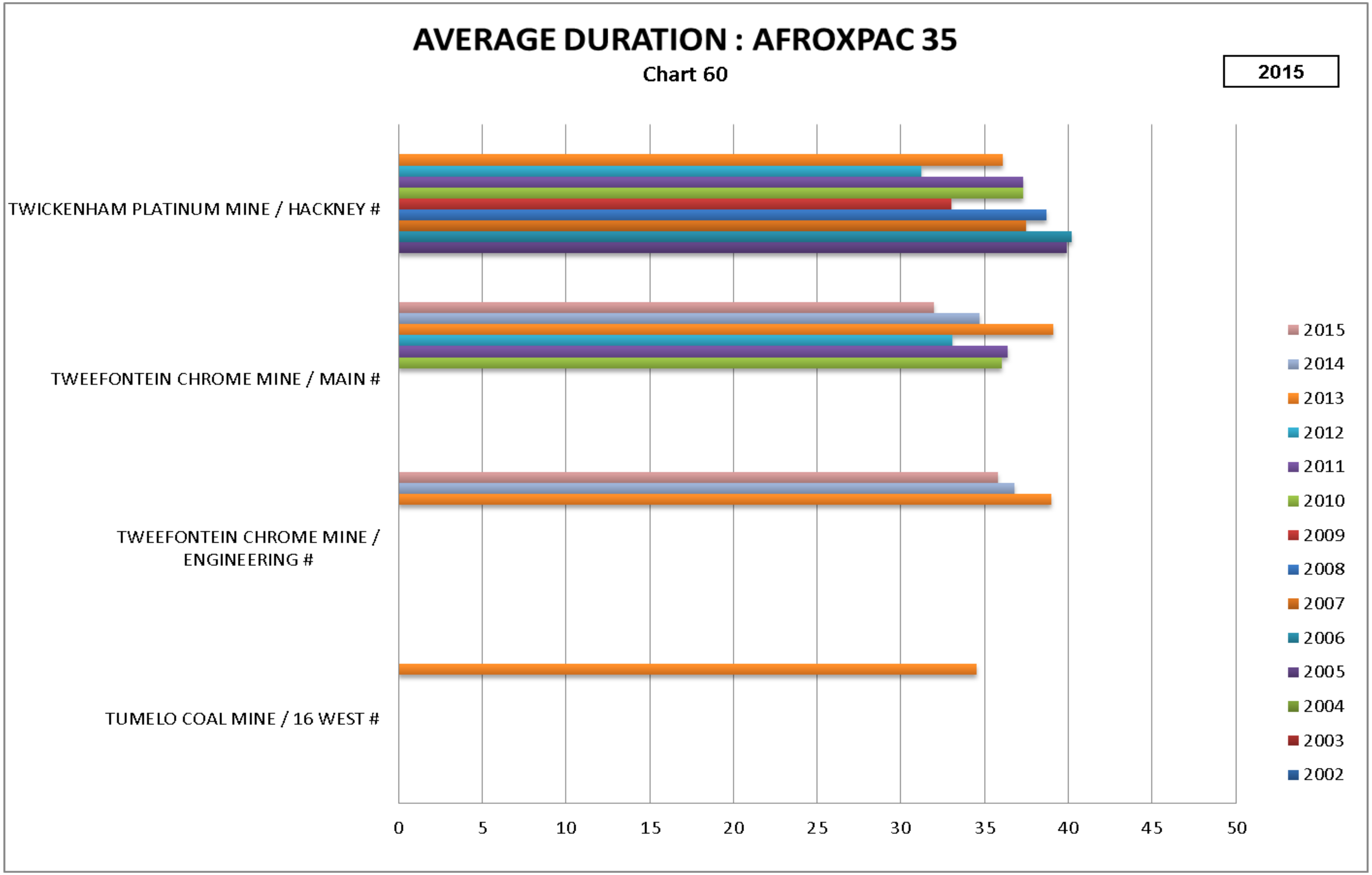
2002


AVERAGE DURATION : AFROXPAC 35
Chart 58
2015
THORNCLIFFE MINE
TAU TONA MINE
TAU LEKOA GOLD MINE
TARGET MINE / 3#
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002


AVERAGE DURATION : AFROXPAC 35
Chart 59
2015
TSHEPONG GOLD MINE
TROJAN NICKEL MINE
TOTAL COAL / TUMELO MINE
THUTSI COLLIERY
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002



AVERAGE DURATION : AFROXPAC 35
Chart 60
2015
TWICKENHAM PLATINUM MINE / HACKNEY #
TWEEFONTEIN CHROME MINE / MAIN #
TWEEFONTEIN CHROME MINE / ENGINEERING #
TUMELO COAL MINE / 16 WEST #
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
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2009
2008
2007
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2003
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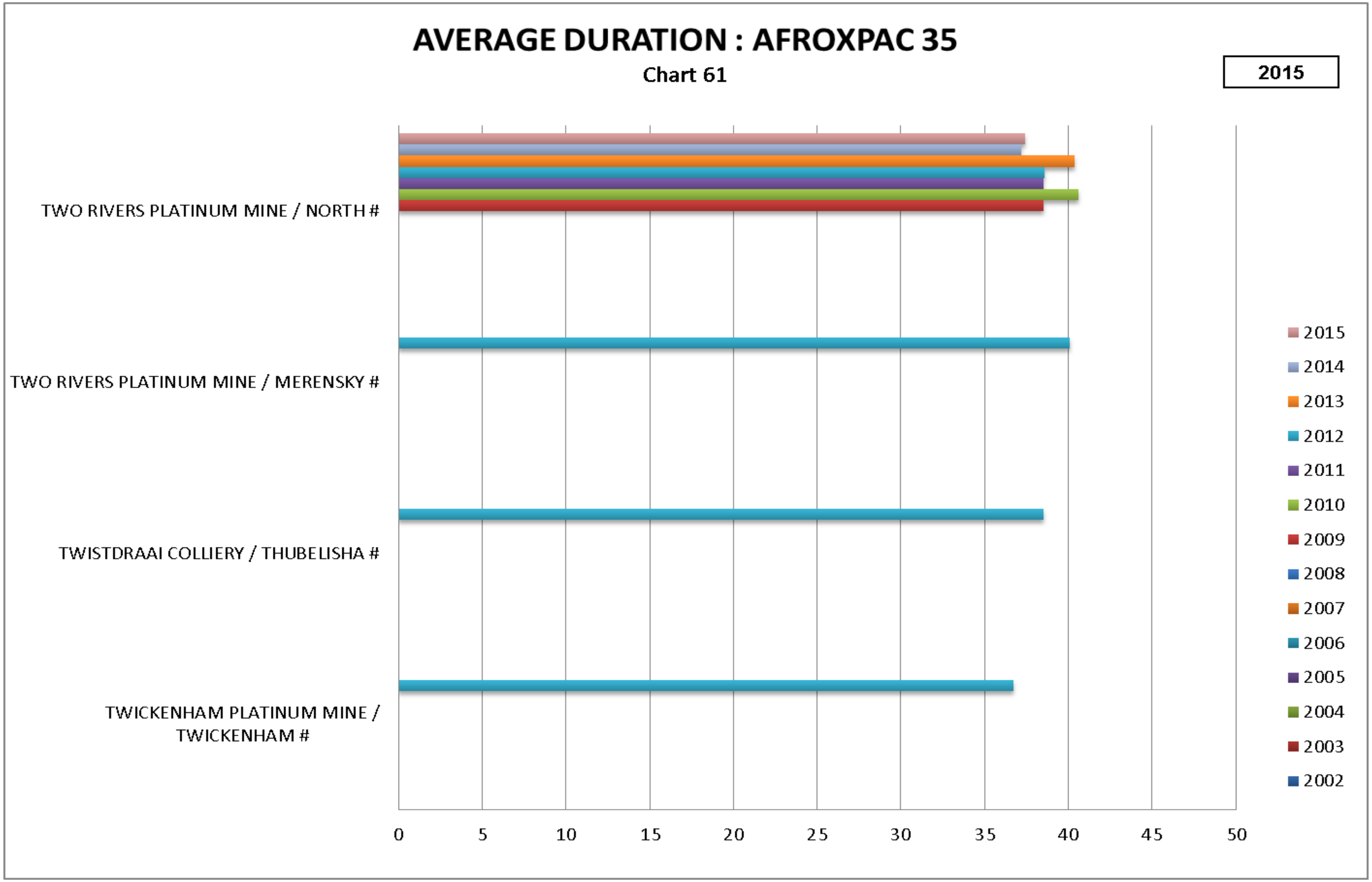
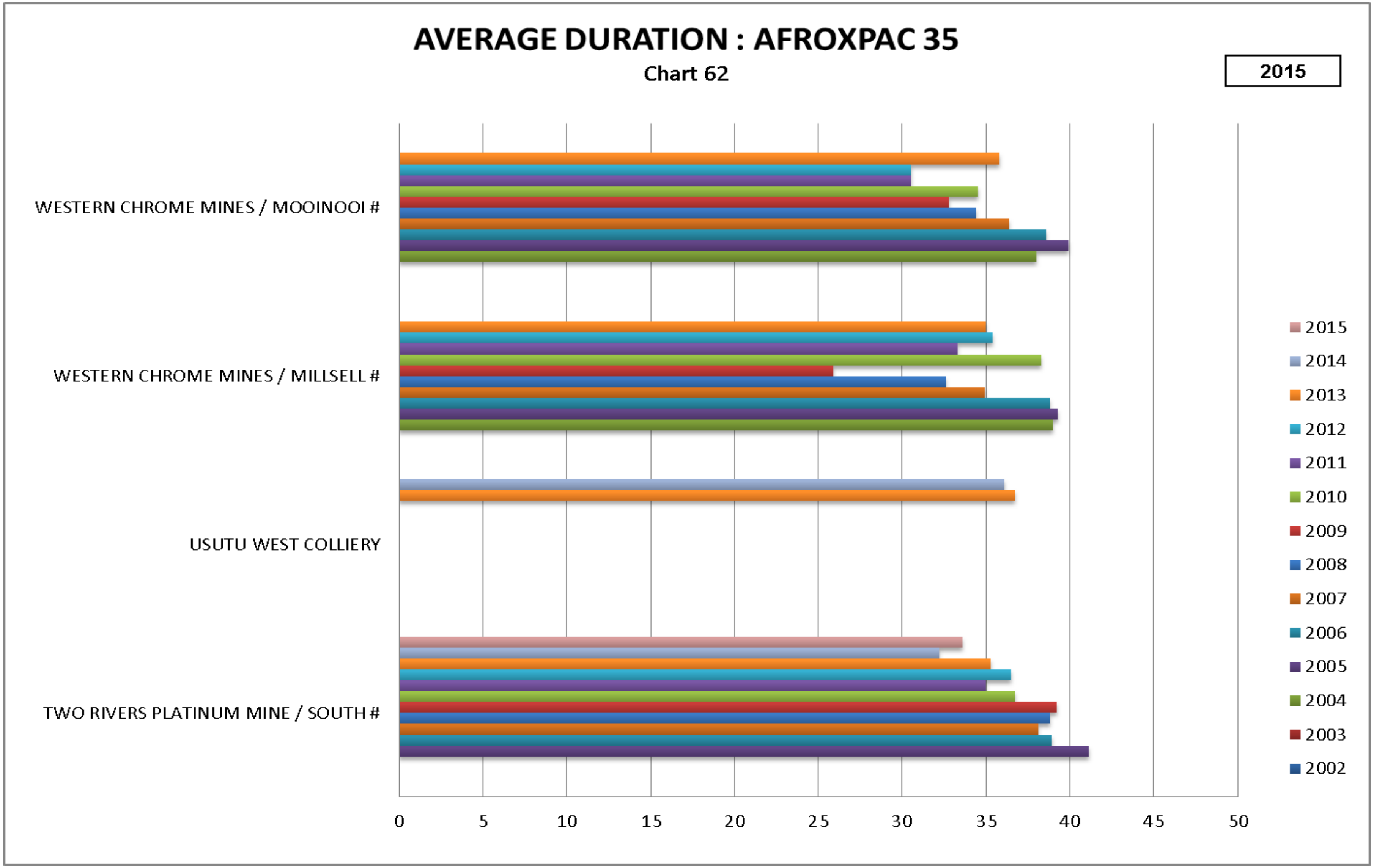


AVERAGE DURATION : AFROXPAC 35
Chart 61
2015
TWO RIVERS PLATINUM MINE / NORTH #
TWO RIVERS PLATINUM MINE / MERENSKY #
TWISTDRAAI COLLIERY / THUBELISHA #
TWICKENHAM PLATINUM MINE / TWICKENHAM #
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002
0
5
10
15
20
25
30
35
40
45
50


AVERAGE DURATION : AFROXPAC 35
Chart 62
2015
WESTERN CHROME MINES / MOOINOOI #
WESTERN CHROME MINES / MILLSELL #
USUTU WEST COLLIERY
TWO RIVERS PLATINUM MINE / SOUTH #
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
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2005
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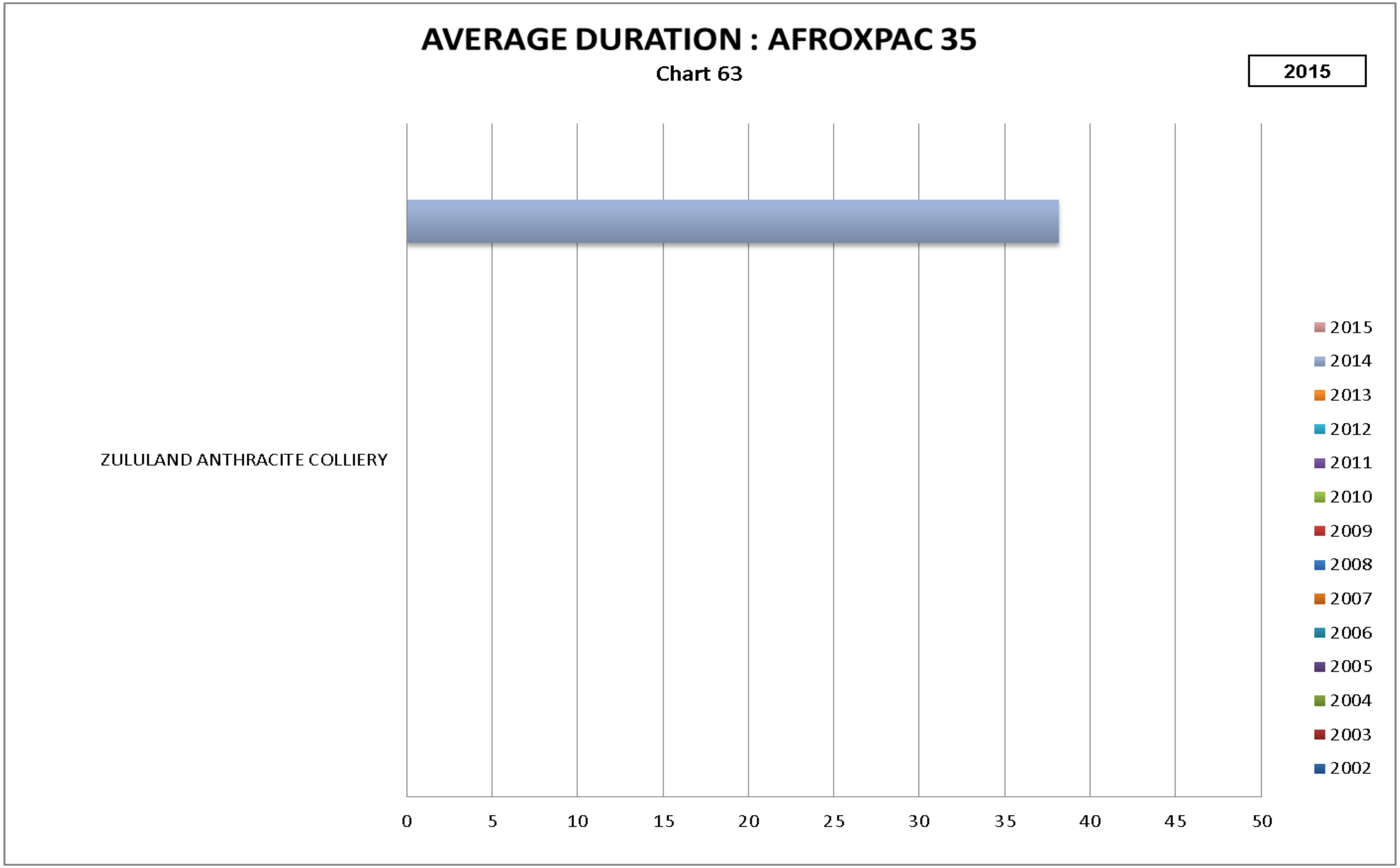
2002



AVERAGE DURATION : AFROXPAC 35
Chart 63
2015
ZULULAND ANTHRACITE COLLIERY
0
5
10
15
20
25
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35
40
45
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2015
2014
2013
2012
2011
2010
2009
2008
2007
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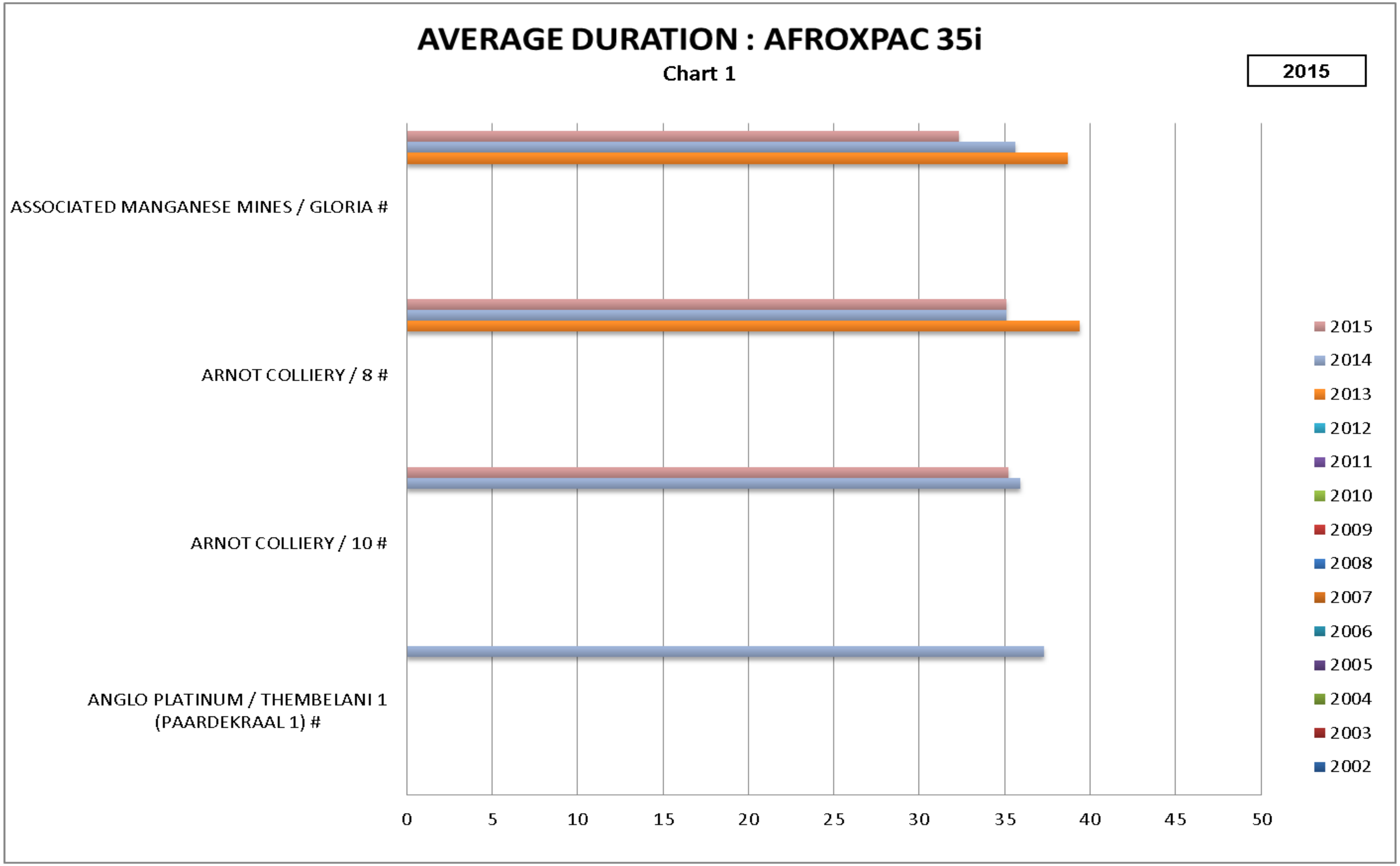
2002


AVERAGE DURATION : AFROXPAC 35i
Chart 1
2015
ASSOCIATED MANGANESE MINES / GLORIA #
ARNOT COLLIERY / 8 #
ARNOT COLLIERY / 10 #
ANGLO PLATINUM / THEMBELANI 1 (PAARDEKRAAL 1) #
0
5
10
15
20
25
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35
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45
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2015
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2009
2008
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2005
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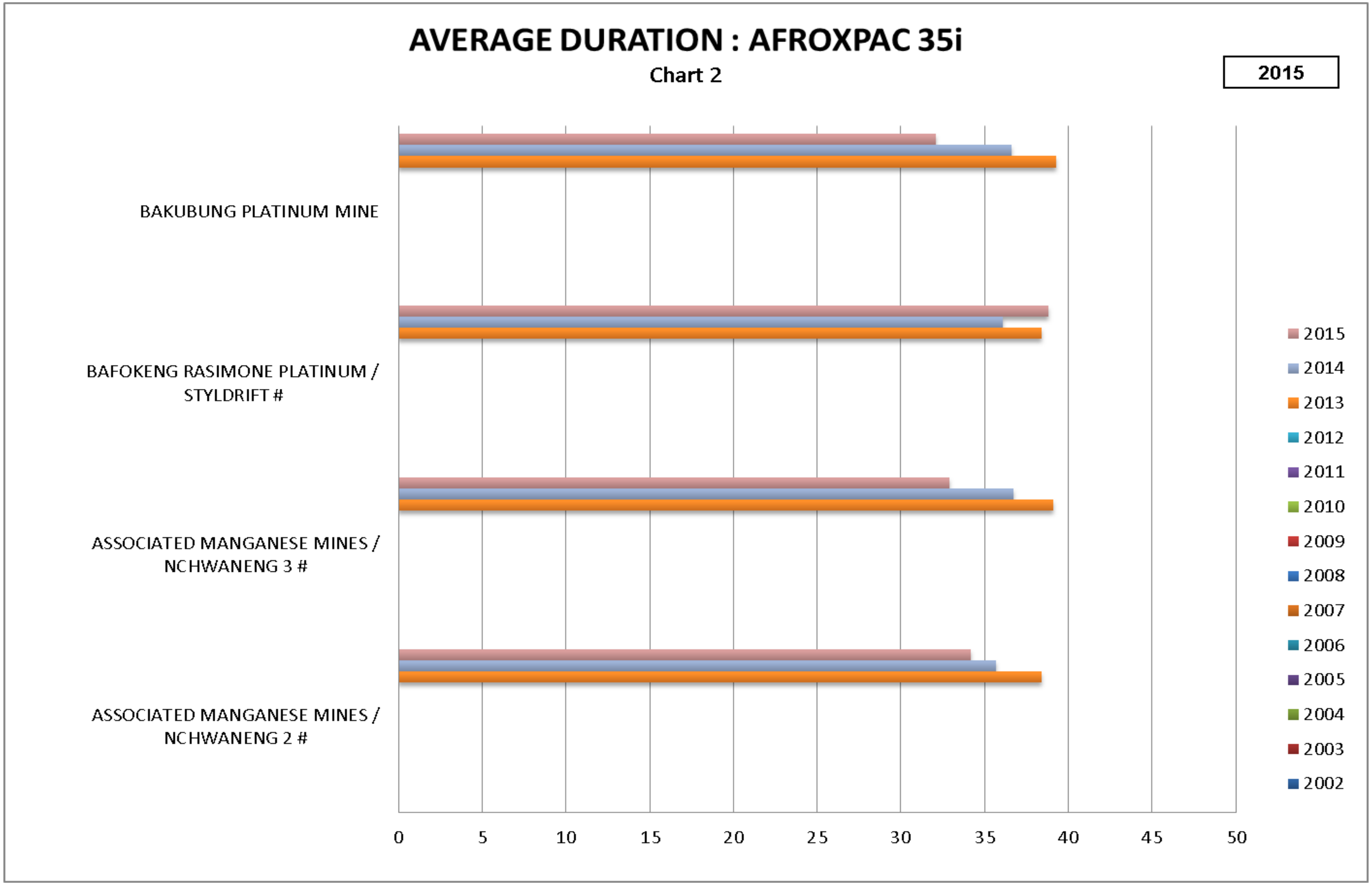
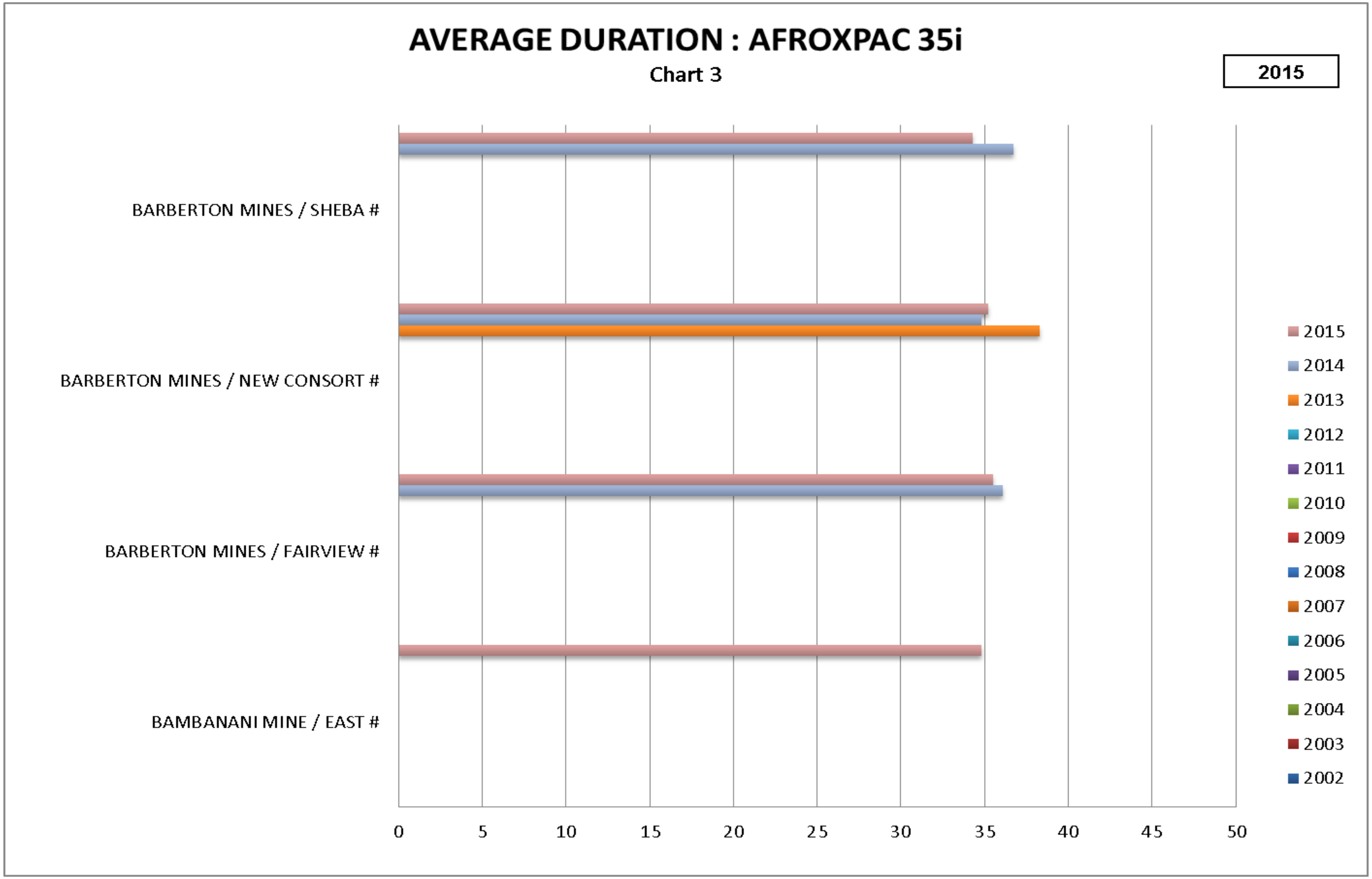
2003
2002


AVERAGE DURATION : AFROXPAC 35i
Chart 2
2015
BAKUBUNG PLATINUM MINE
BAFOKENG RASIMONE PLATINUM / STYLDRIFT #
ASSOCIATED MANGANESE MINES / NCHWANENG 3 #
ASSOCIATED MANGANESE MINES / NCHWANENG 2 #
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002


AVERAGE DURATION : AFROXPAC 35i
Chart 3
2015
BARBERTON MINES / SHEBA #
BARBERTON MINES / NEW CONSORT #
BARBERTON MINES / FAIRVIEW #
BAMBANANI MINE / EAST #
0
5
10
15
20
25
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2015
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2013
2012
2011
2010
2009
2008
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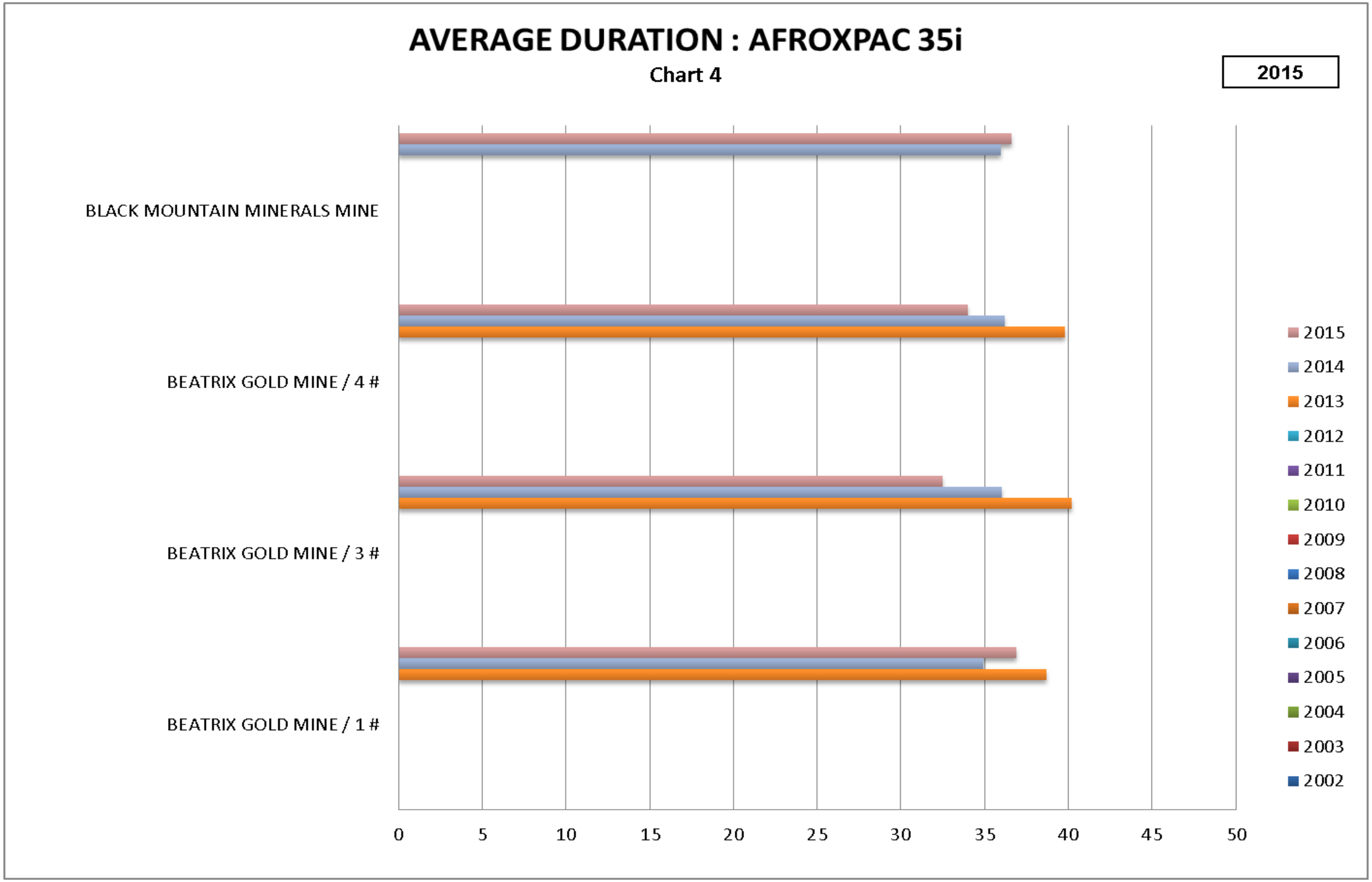
AVERAGE DURATION : AFROXPAC 35i
Chart 4
2015
BLACK MOUNTAIN MINERALS MINE
BEATRIX GOLD MINE / 4 #
BEATRIX GOLD MINE / 3 #
BEATRIX GOLD MINE / 1 #
0
5
10
15
20
25
30
35
40
45
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2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
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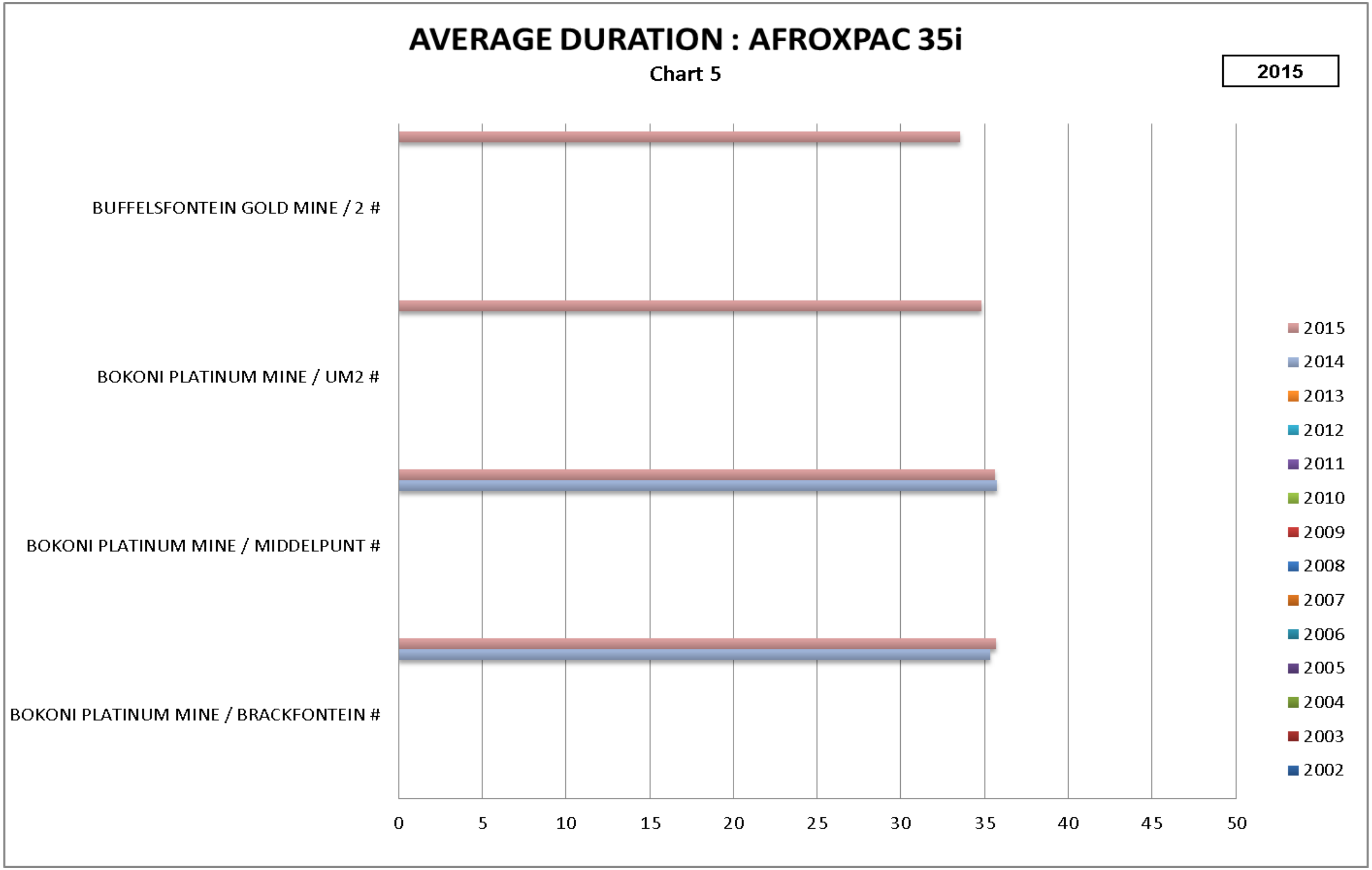
2004
2003
2002


AVERAGE DURATION : AFROXPAC 35i
Chart 5
2015
BUFFELSFONTEIN GOLD MINE / 2 #
BOKONI PLATINUM MINE / UM2 #
BOKONI PLATINUM MINE / MIDDELPUNT #
BOKONI PLATINUM MINE / BRACKFONTEIN #
0
5
10
15
20
25
30
35
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45
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2015
2014
2013
2012
2011
2010
2009
2008
2007
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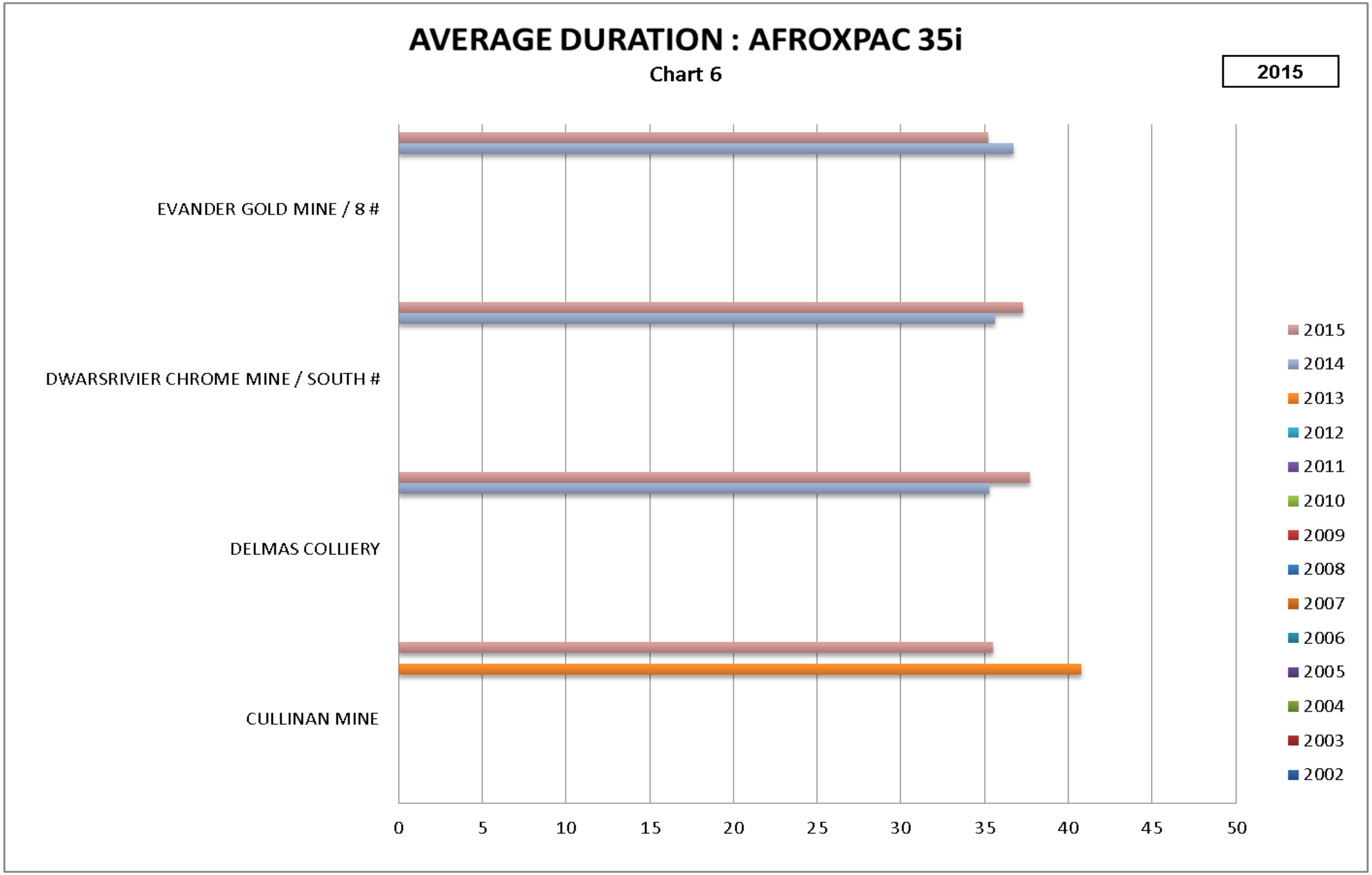

AVERAGE DURATION : AFROXPAC 35i
Chart 6
2015
EVANDER GOLD MINE / 8 #
DWARSRIVIER CHROME MINE / SOUTH #
DELMAS COLLIERY
CULLINAN MINE
0
5
10
15
20
25
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2015
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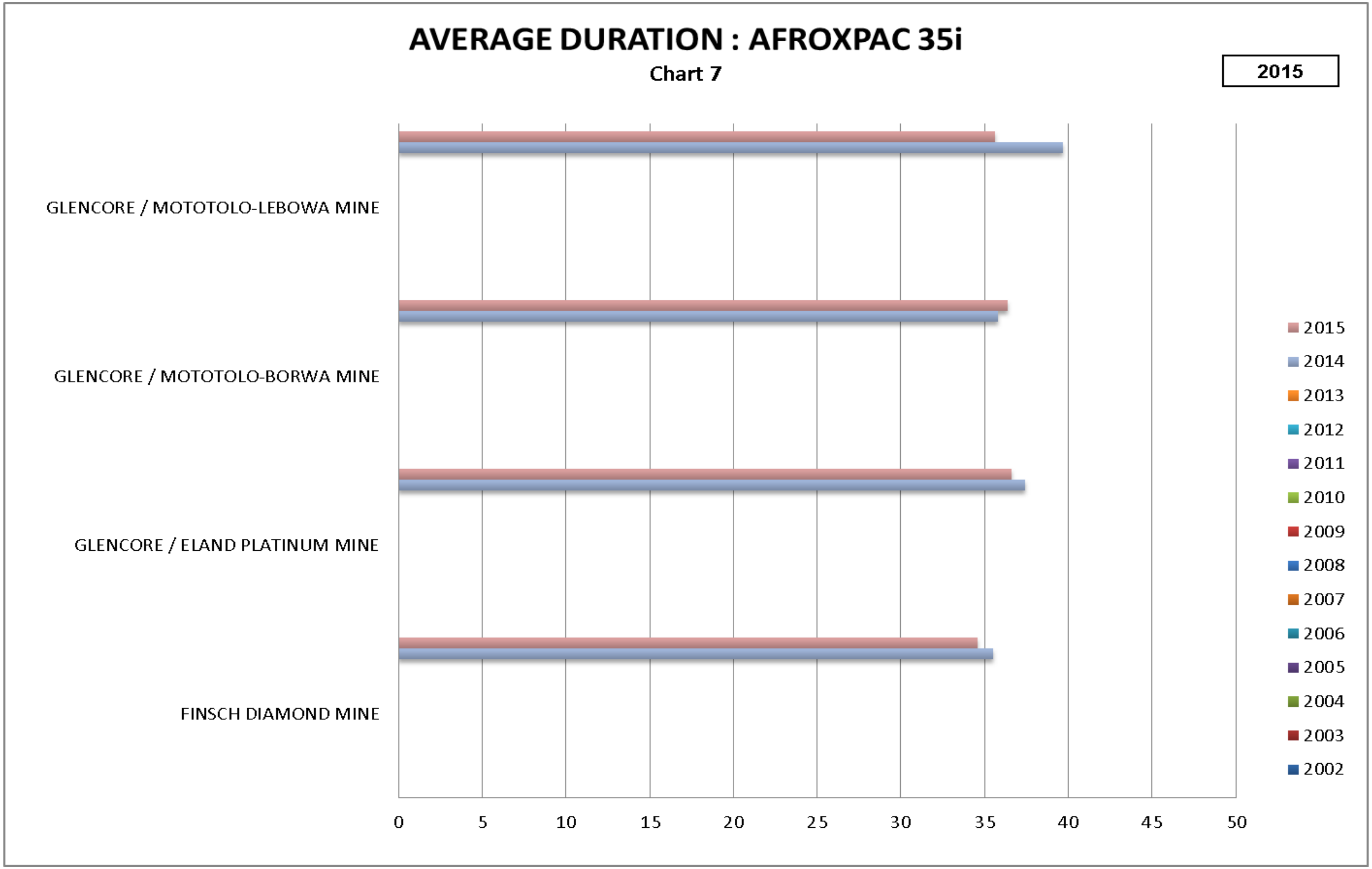
AVERAGE DURATION : AFROXPAC 35i
Chart 7
2015
GLENCORE / MOTOTOLO-LEBOWA MINE
GLENCORE / MOTOTOLO-BORWA MINE
GLENCORE / ELAND PLATINUM MINE
FINSCH DIAMOND MINE
0
5
10
15
20
25
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35
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2015
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2009
2008
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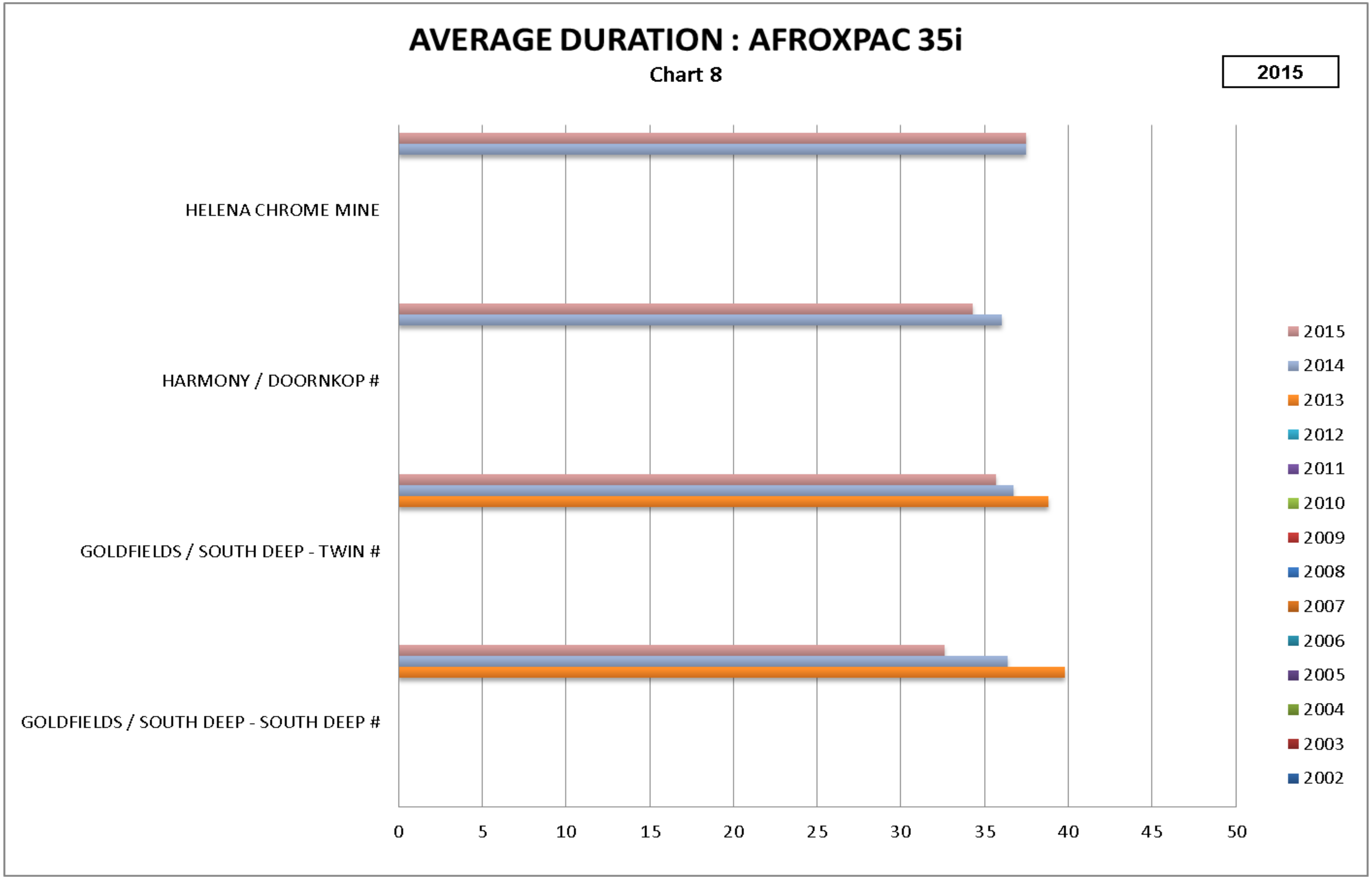
AVERAGE DURATION : AFROXPAC 35i
Chart 8
2015
HELENA CHROME MINE
HARMONY / DOORNKOP #
GOLDFIELDS / SOUTH DEEP - TWIN #
GOLDFIELDS / SOUTH DEEP - SOUTH DEEP #
0
5
10
15
20
25
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2015
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2010
2009
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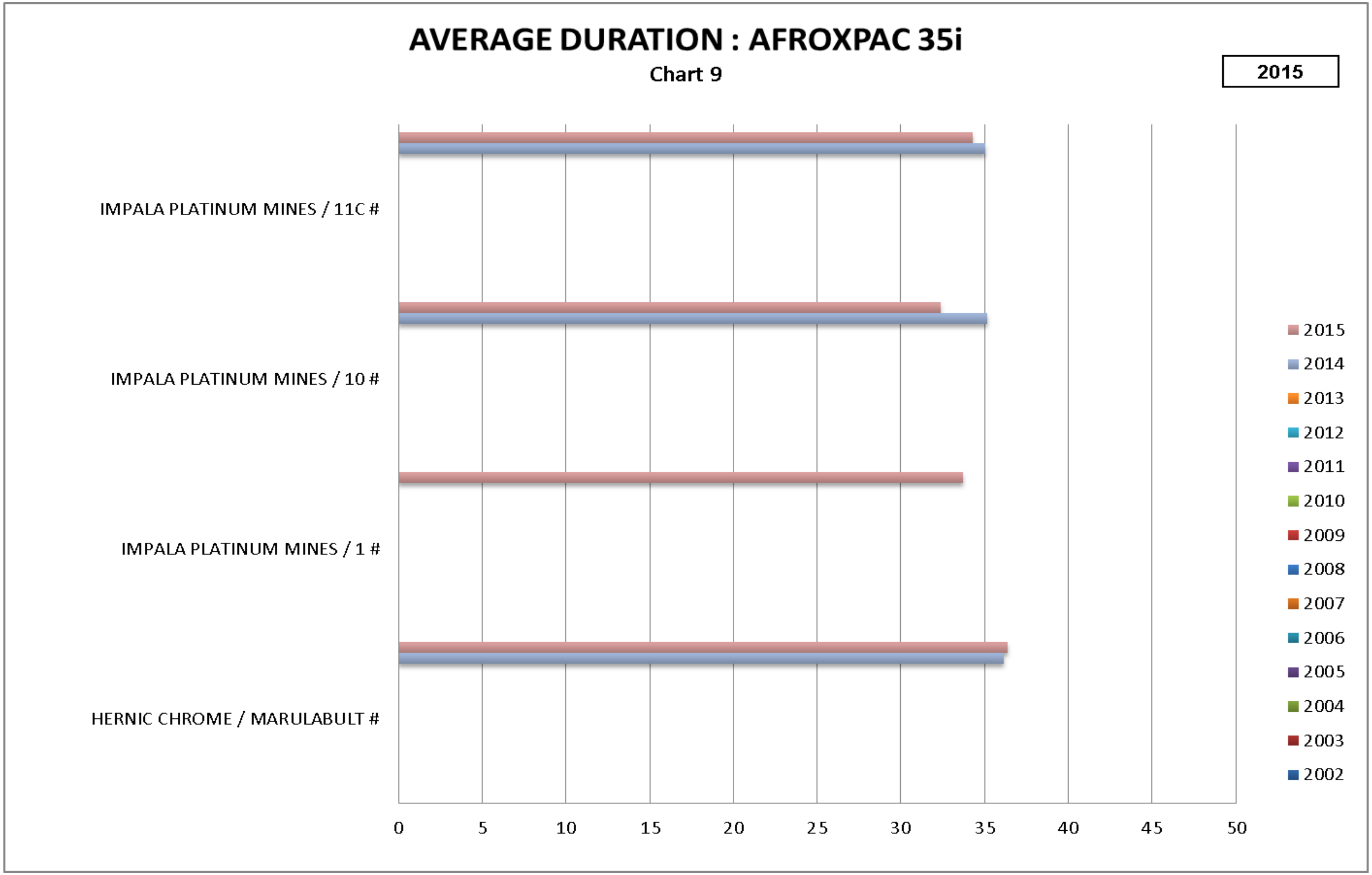
AVERAGE DURATION : AFROXPAC 35i
Chart 9
2015
IMPALA PLATINUM MINES / 11C #
IMPALA PLATINUM MINES / 10 #
IMPALA PLATINUM MINES / 1 #
HERNIC CHROME / MARULABULT #
0
5
10
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2015
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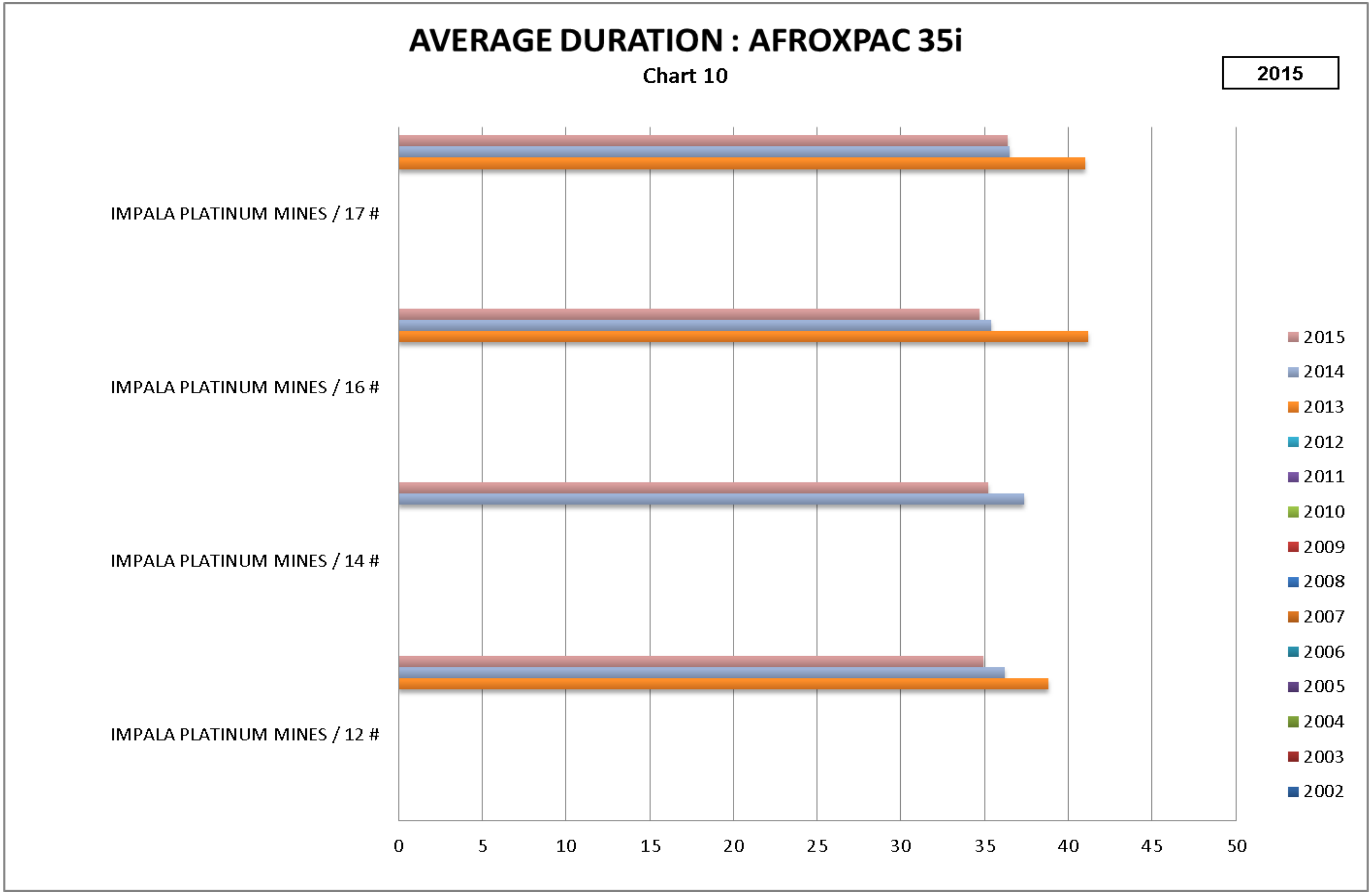
AVERAGE DURATION : AFROXPAC 35i
Chart 10
2015
IMPALA PLATINUM MINES / 17 #
IMPALA PLATINUM MINES / 16 #
IMPALA PLATINUM MINES / 14 #
IMPALA PLATINUM MINES / 12 #
0
5
10
15
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2015
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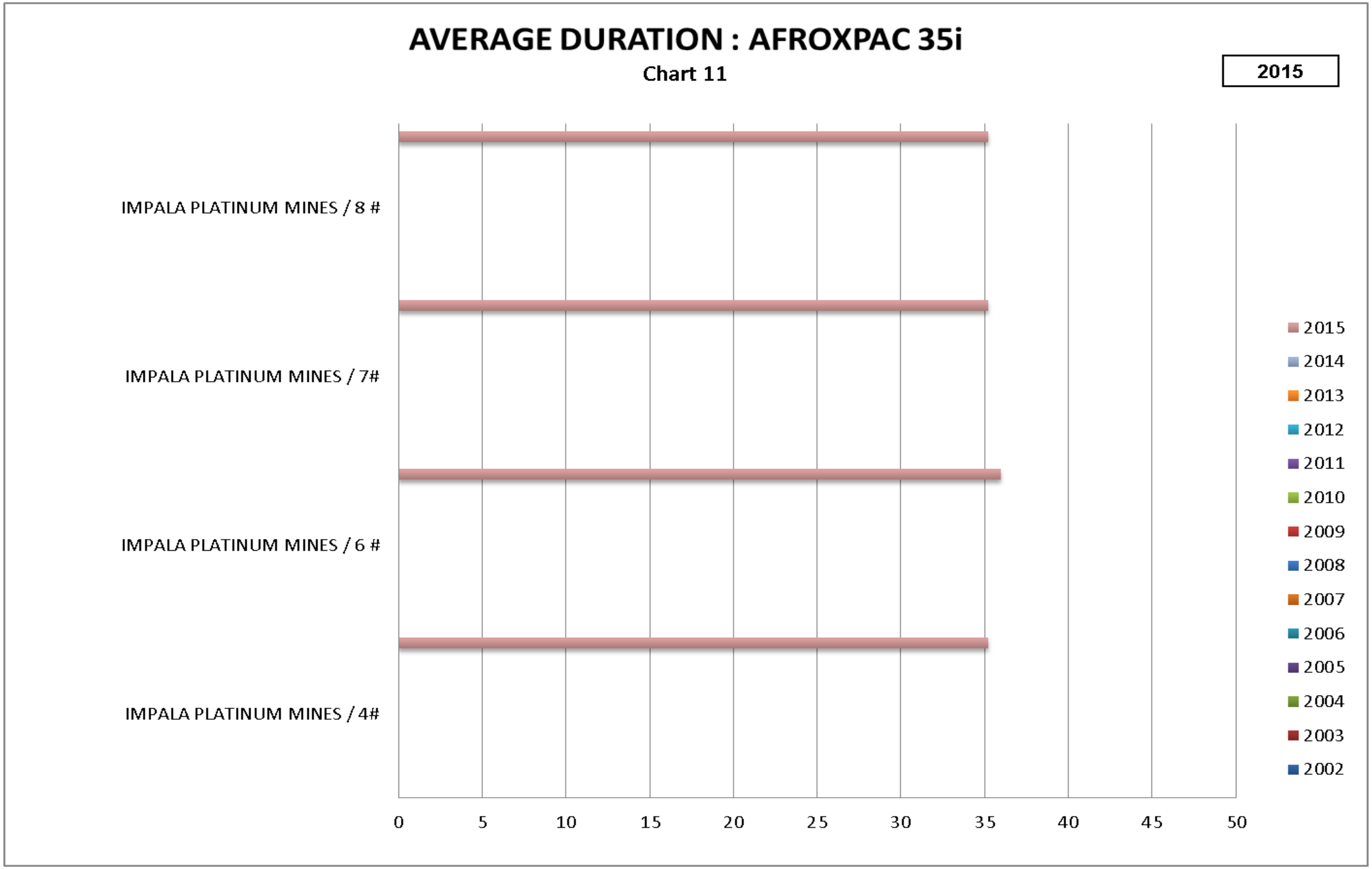
AVERAGE DURATION : AFROXPAC 35i
Chart 11
2015
IMPALA PLATINUM MINES / 8 #
IMPALA PLATINUM MINES / 7#
IMPALA PLATINUM MINES / 6 #
IMPALA PLATINUM MINES / 4#
0
5
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2015
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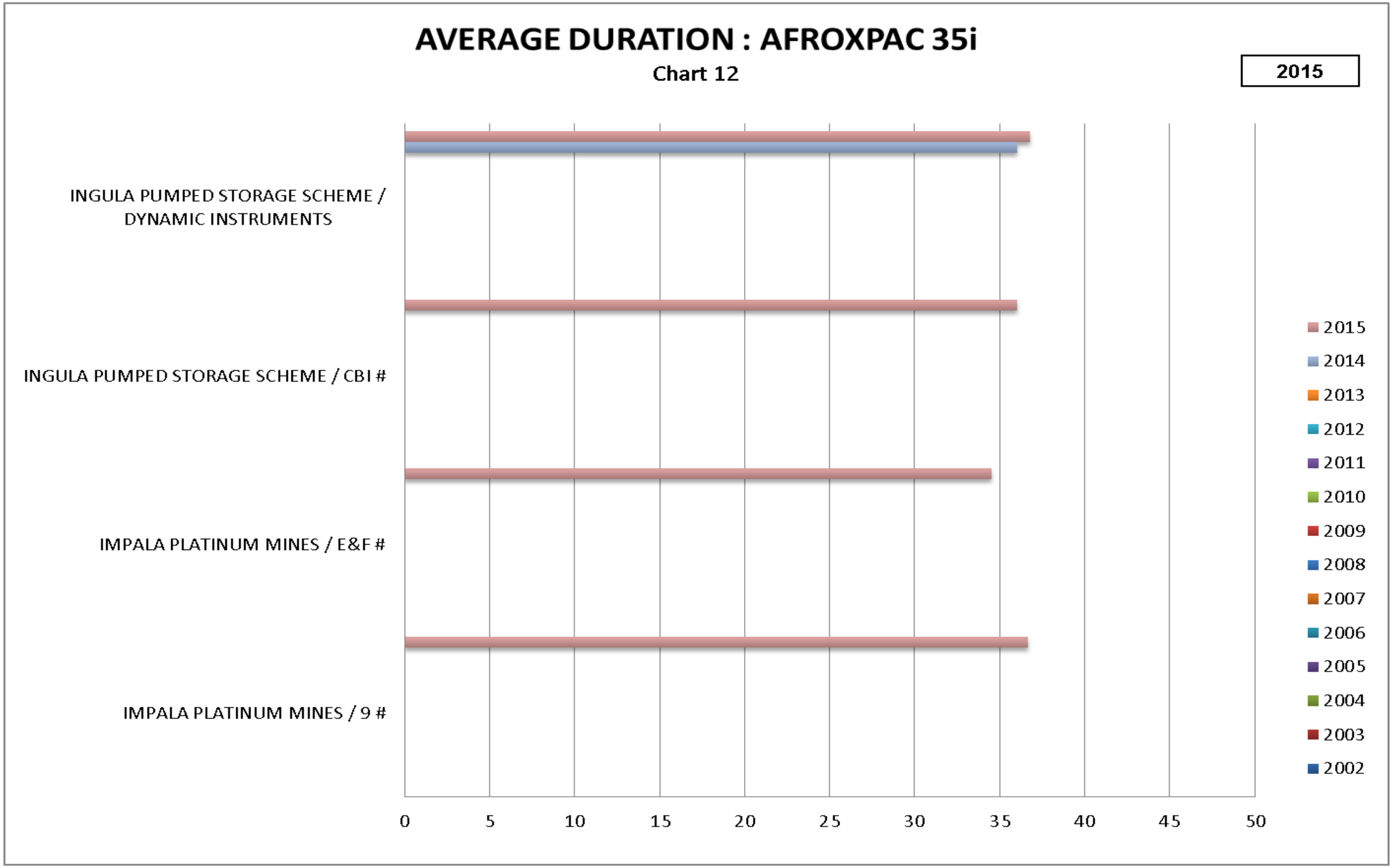

AVERAGE DURATION : AFROXPAC 35i
Chart 12
2015
INGULA PUMPED STORAGE SCHEME / DYNAMIC INSTRUMENTS
INGULA PUMPED STORAGE SCHEME / CBI #
IMPALA PLATINUM MINES / E&F #
IMPALA PLATINUM MINES / 9 #
0
5
10
15
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2015
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2012
2011
2010
2009
2008
2007
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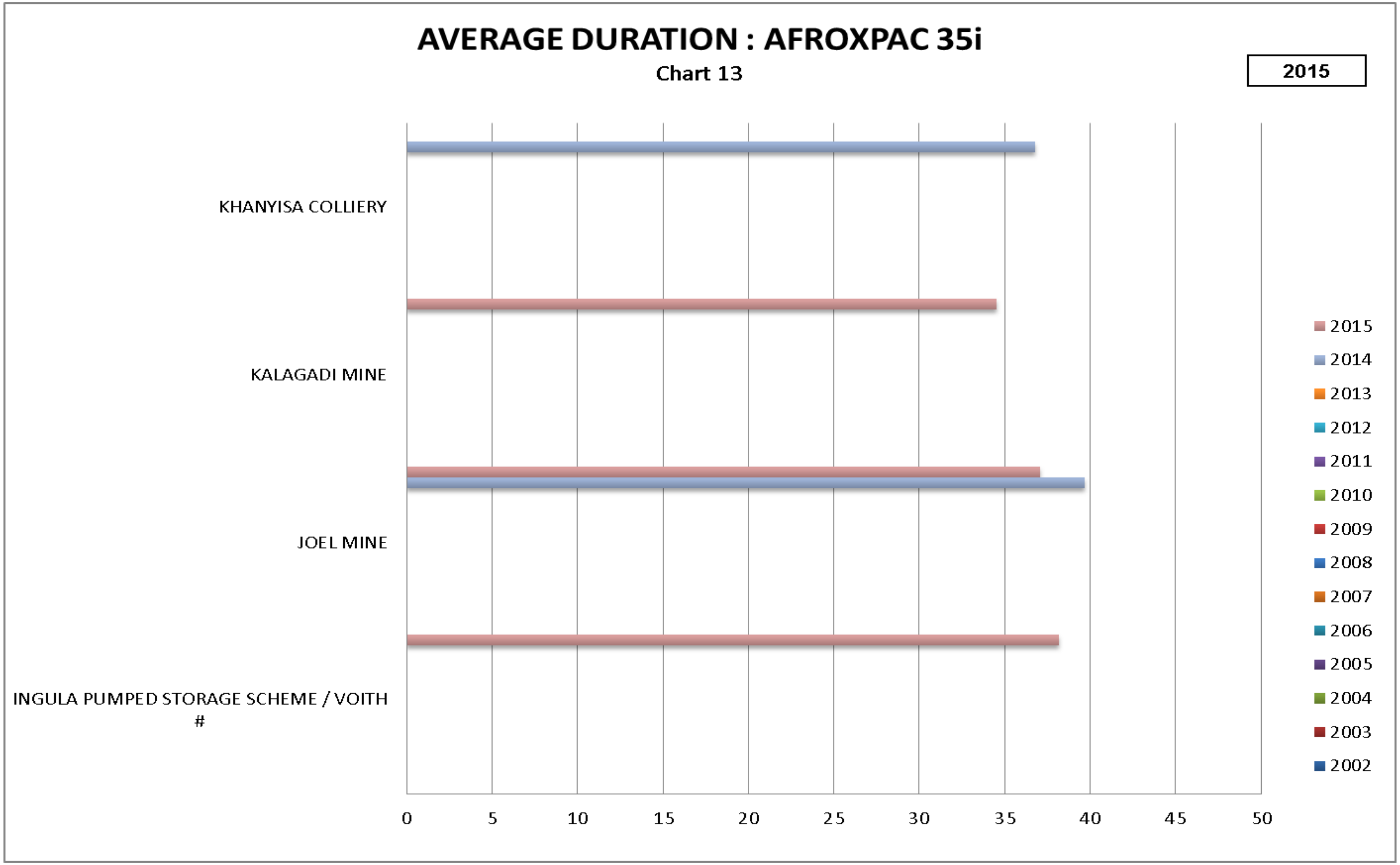
2002


AVERAGE DURATION : AFROXPAC 35i
Chart 13
2015
KHANYISA COLLIERY
KALAGADI MINE
JOEL MINE
INGULA PUMPED STORAGE SCHEME / VOITH #
0
5
10
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2015
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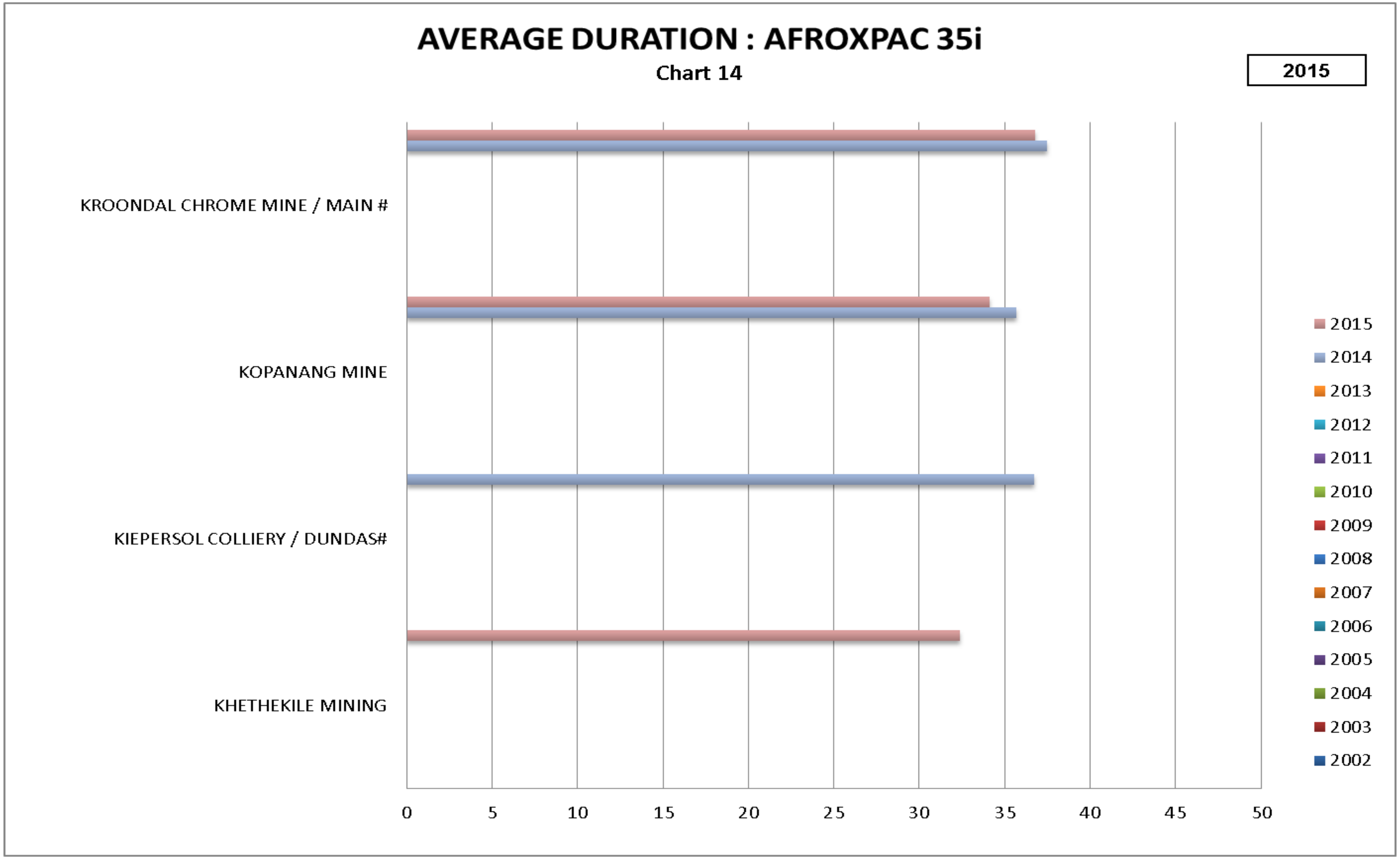
AVERAGE DURATION : AFROXPAC 35i
Chart 14
2015
KROONDAL CHROME MINE / MAIN #
KOPANANG MINE
KIEPERSOL COLLIERY / DUNDAS#
KHETHEKILE MINING
0
5
10
15
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2015
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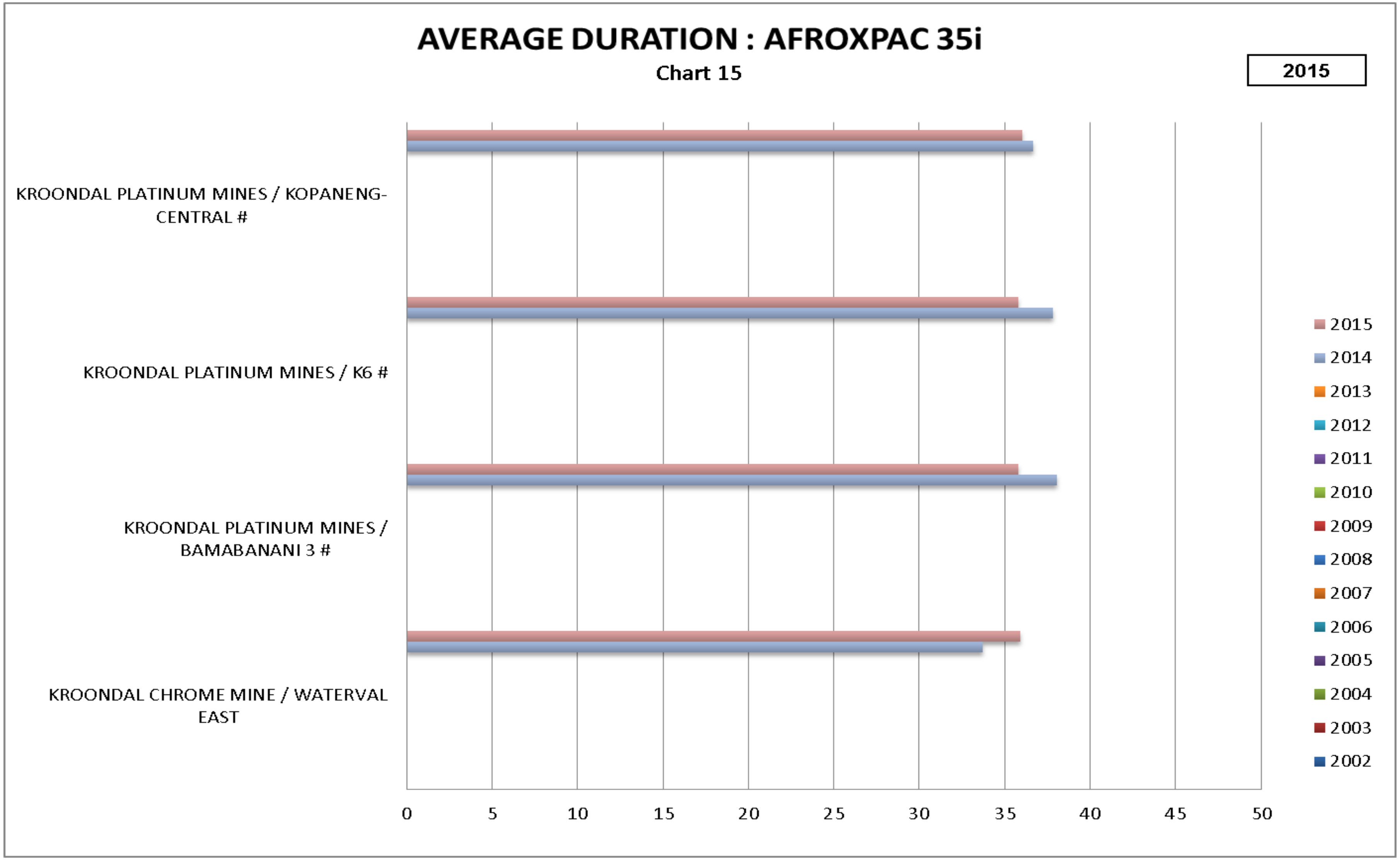

AVERAGE DURATION : AFROXPAC 35i
Chart 15
2015
KROONDAL PLATINUM MINES / KOPANENG-CENTRAL #
KROONDAL PLATINUM MINES / K6 #
KROONDAL PLATINUM MINES / BAMABANANI 3 #
KROONDAL CHROME MINE / WATERVAL EAST
0
5
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2015
2014
2013
2012
2011
2010
2009
2008
2007
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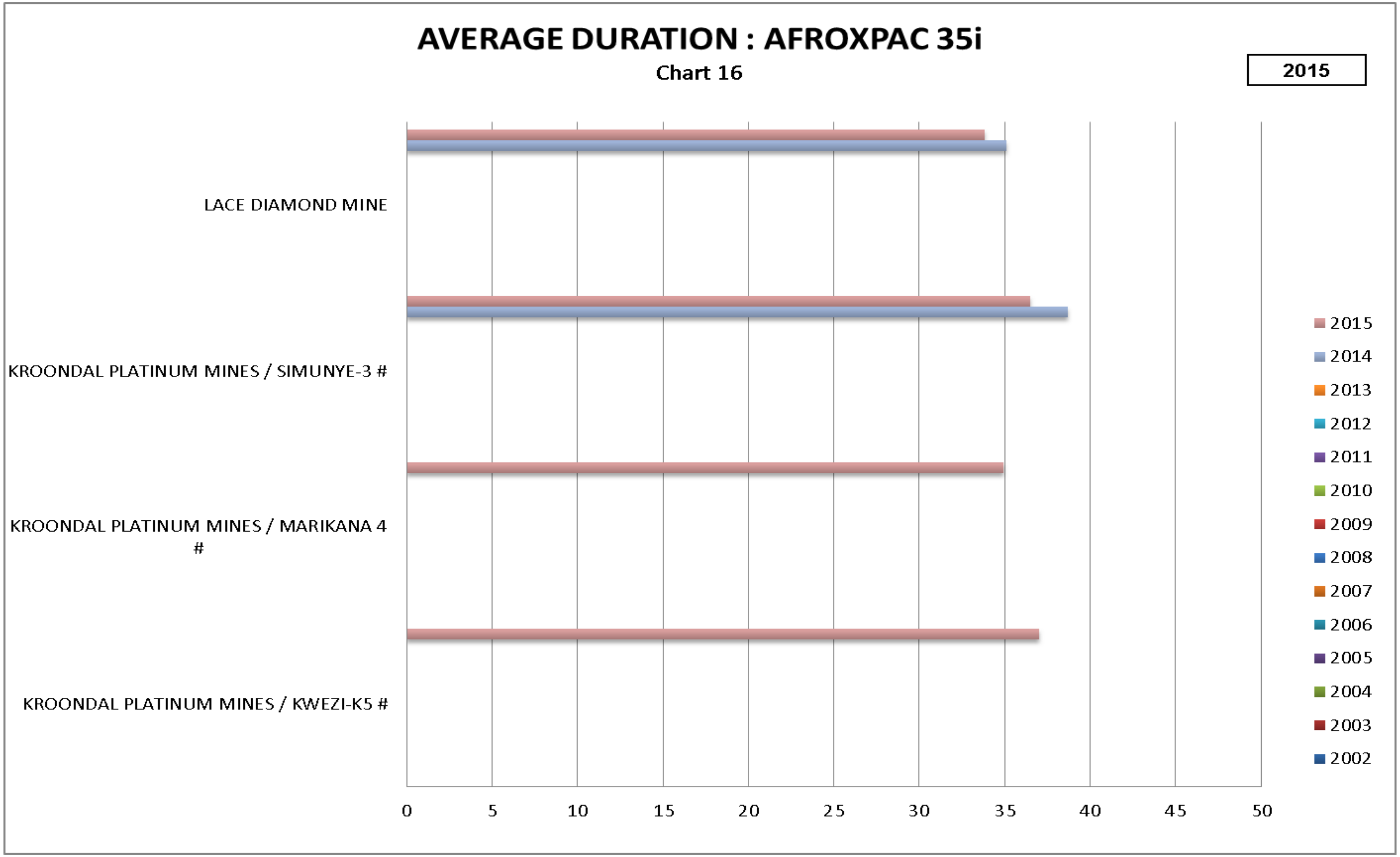
AVERAGE DURATION : AFROXPAC 35i
Chart 16
2015
LACE DIAMOND MINE
KROONDAL PLATINUM MINES / SIMUNYE-3 #
KROONDAL PLATINUM MINES / MARIKANA 4 #
KROONDAL PLATINUM MINES / KWEZI-K5 #
0
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2015
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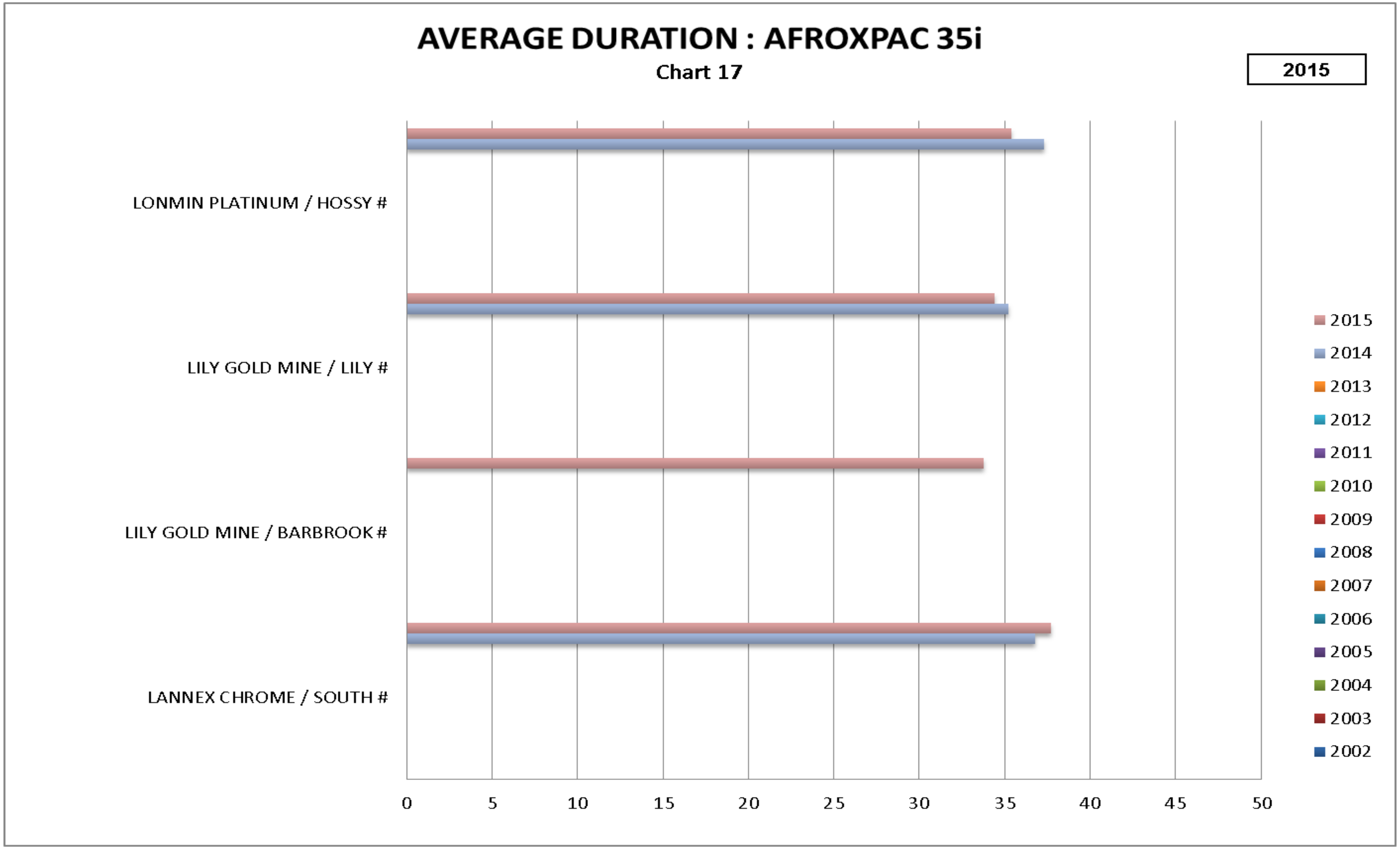
AVERAGE DURATION : AFROXPAC 35i
Chart 17
2015
LONMIN PLATINUM / HOSSY #
LILY GOLD MINE / LILY #
LILY GOLD MINE / BARBROOK #
LANNEX CHROME / SOUTH #
0
5
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2015
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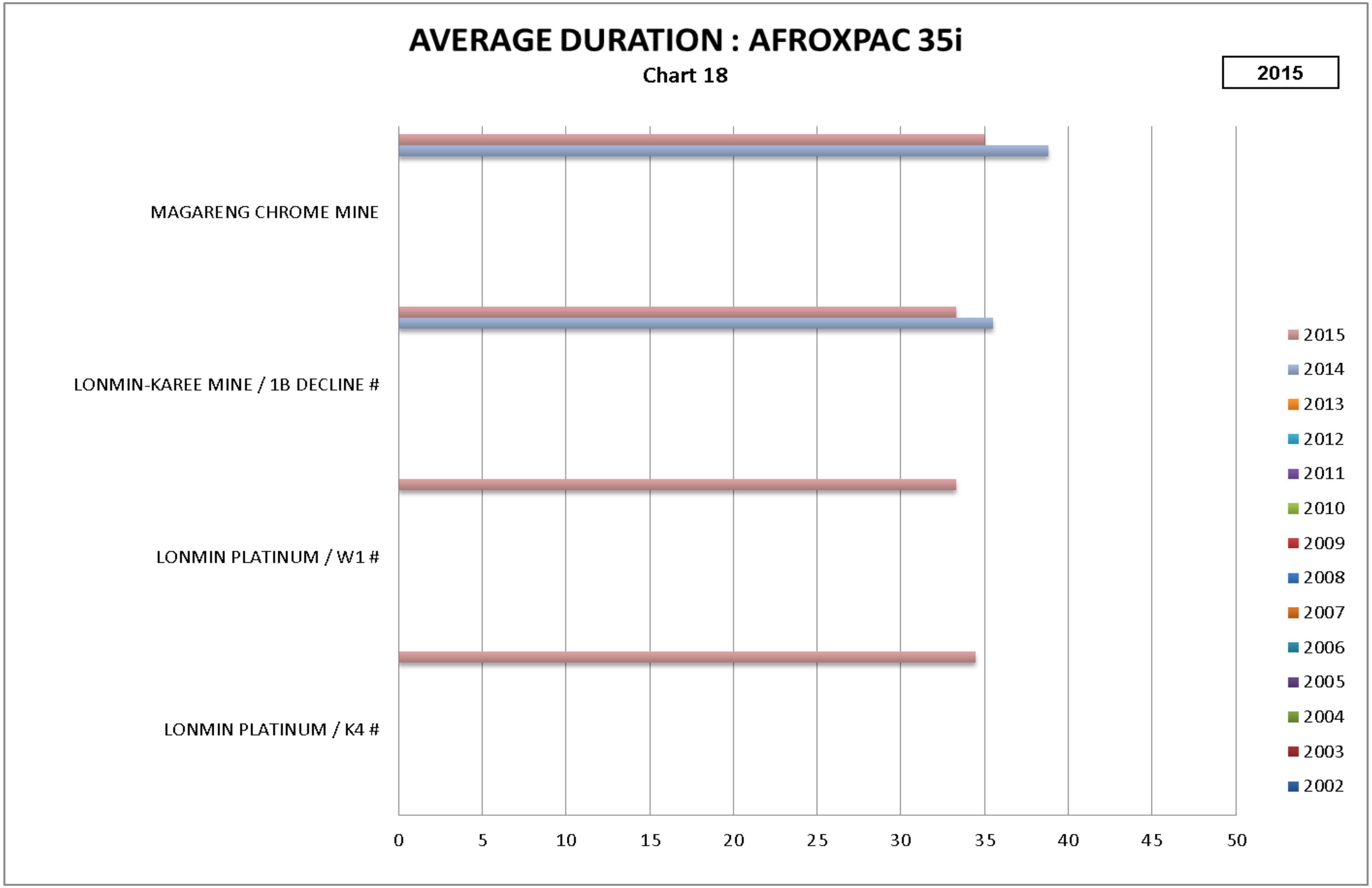

AVERAGE DURATION : AFROXPAC 35i
Chart 18
2015
MAGARENG CHROME MINE
LONMIN-KAREE MINE / 1B DECLINE #
LONMIN PLATINUM / W1 #
LONMIN PLATINUM / K4 #
0
5
10
15
20
25
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45
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2015
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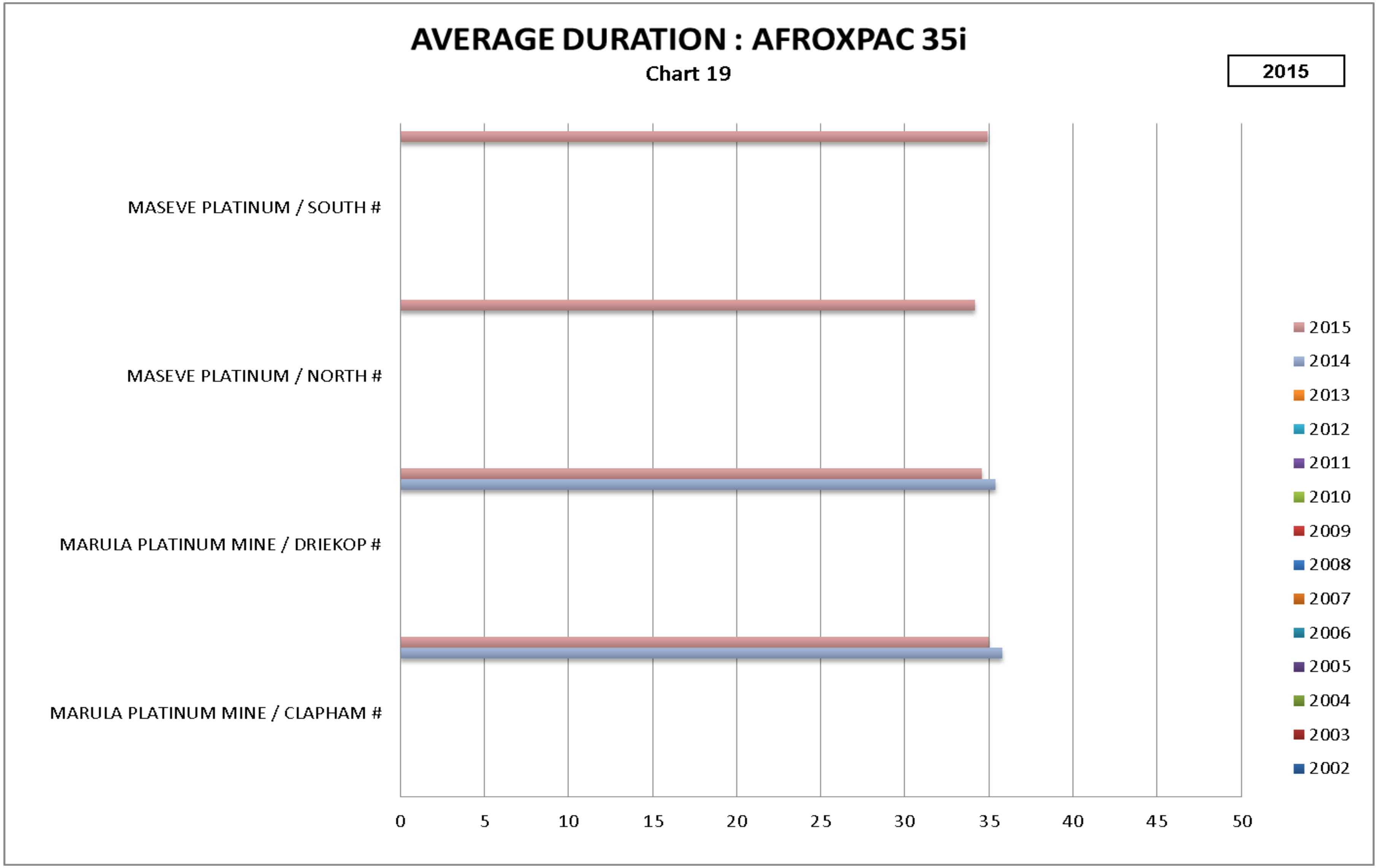

AVERAGE DURATION : AFROXPAC 35i
Chart 19
2015
MASEVE PLATINUM / SOUTH #
MASEVE PLATINUM / NORTH #
MARULA PLATINUM MINE / DRIEKOP #
MARULA PLATINUM MINE / CLAPHAM #
0
5
10
15
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2015
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2013
2012
2011
2010
2009
2008
2007
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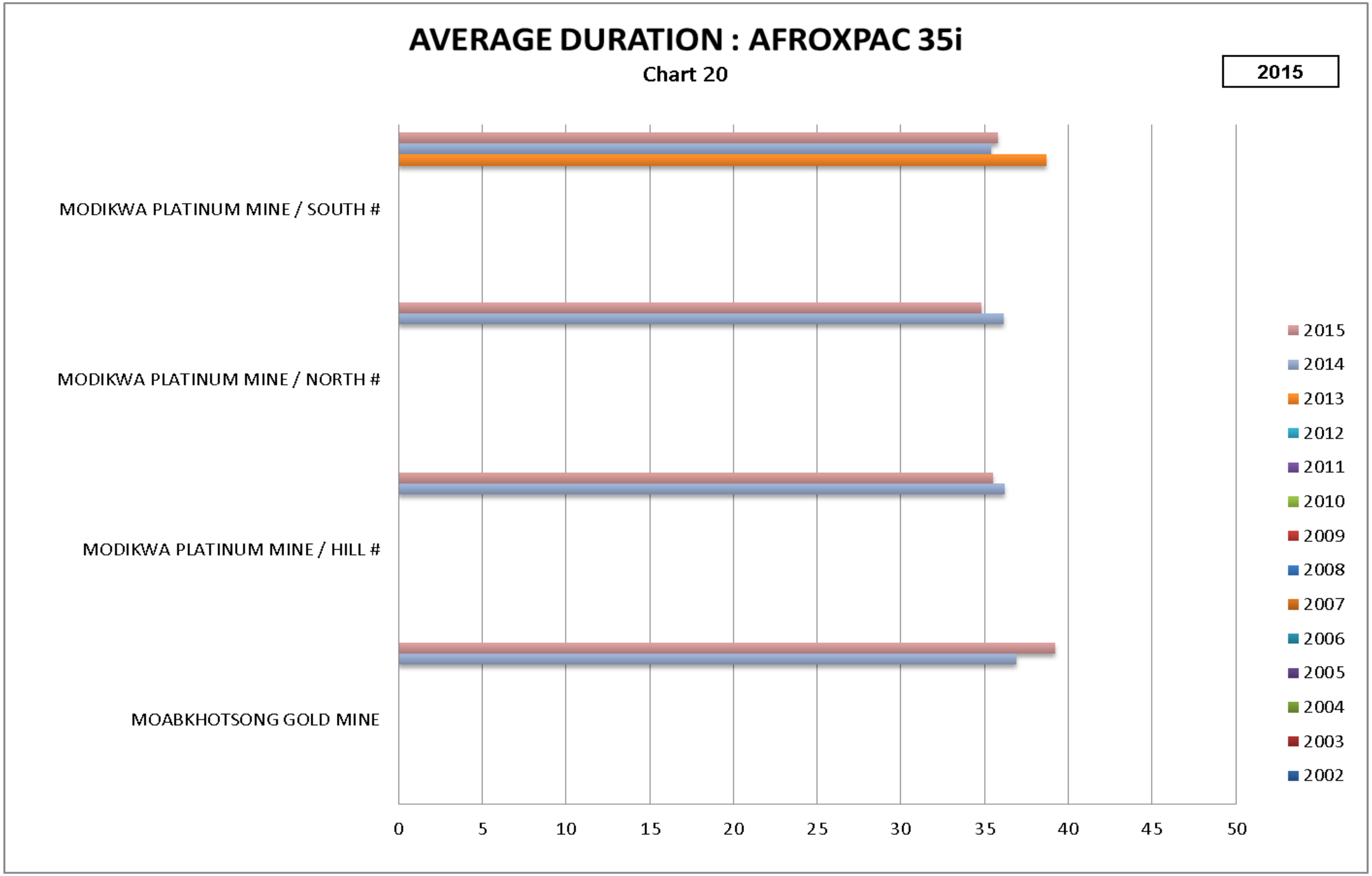
AVERAGE DURATION : AFROXPAC 35i
Chart 20
2015
MODIKWA PLATINUM MINE / SOUTH #
MODIKWA PLATINUM MINE / NORTH #
MODIKWA PLATINUM MINE / HILL #
MOABKHOTSONG GOLD MINE
0
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2011
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2009
2008
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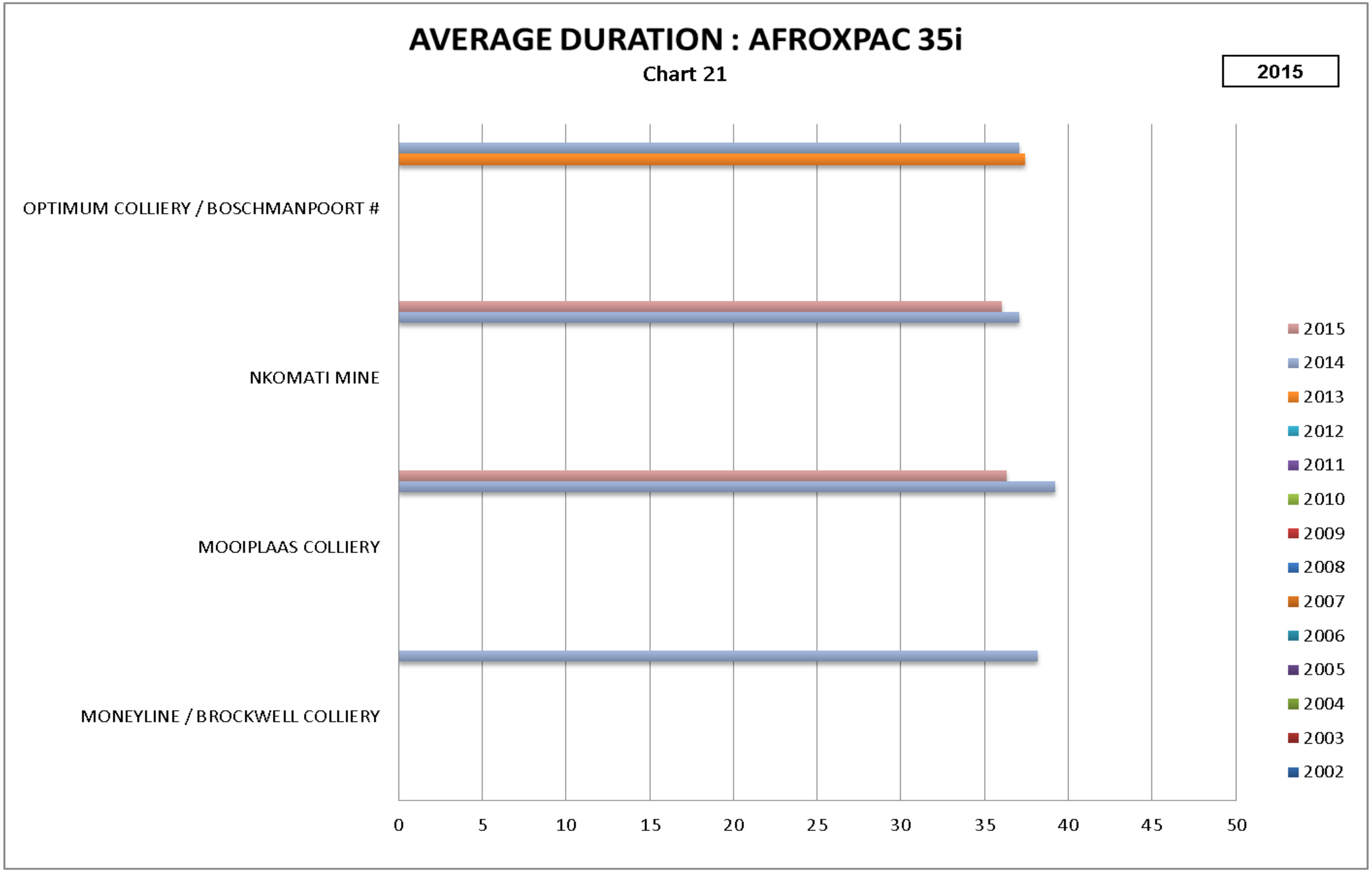
AVERAGE DURATION : AFROXPAC 35i
Chart 21
2015
OPTIMUM COLLIERY / BOSCHMANPOORT #
NKOMATI MINE
MOOIPLAAS COLLIERY
MONEYLINE / BROCKWELL COLLIERY
0
5
10
15
20
25
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2015
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2013
2012
2011
2010
2009
2008
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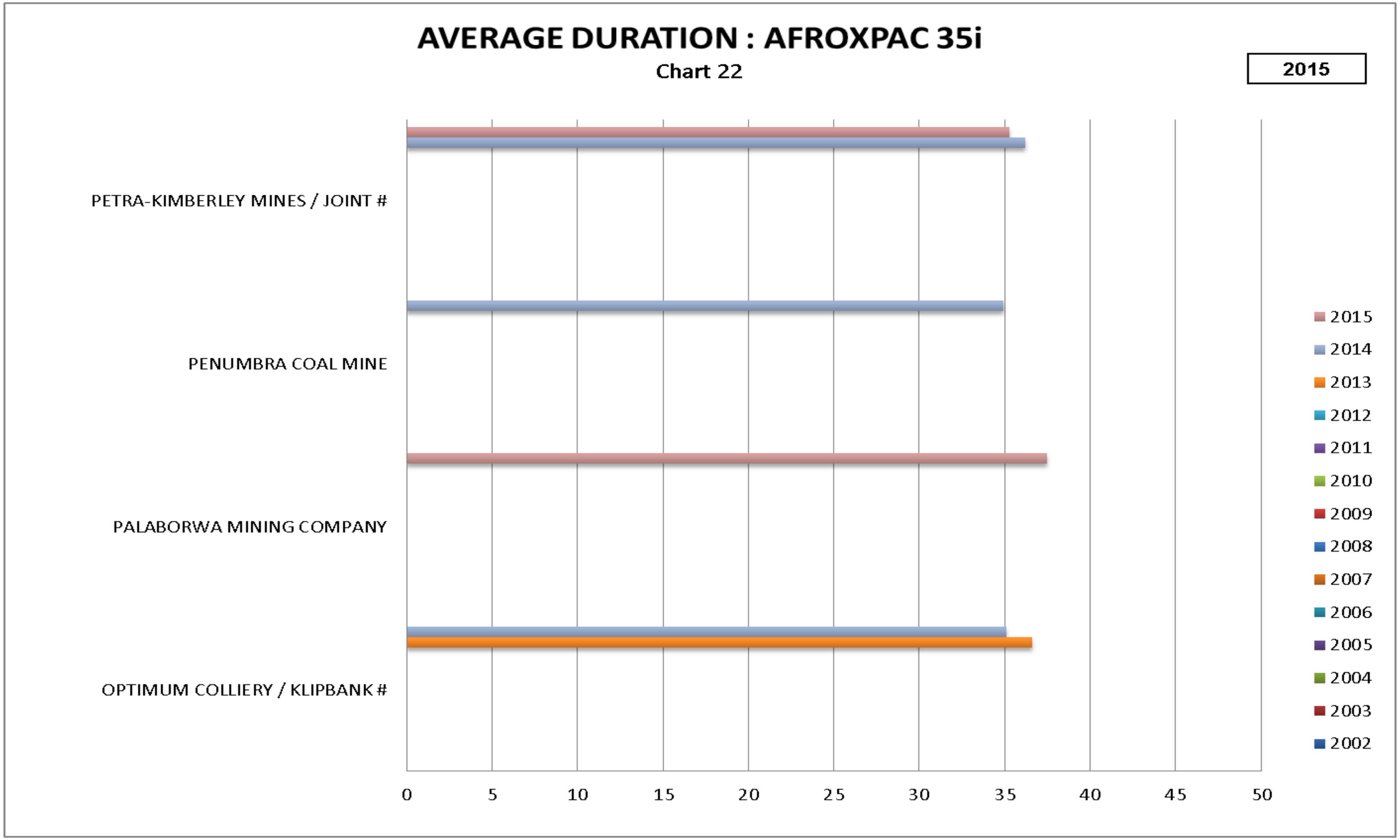
AVERAGE DURATION : AFROXPAC 35i
Chart 22
2015
PETRA-KIMBERLEY MINES / JOINT #
PENUMBRA COAL MINE
PALABORWA MINING COMPANY
OPTIMUM COLLIERY / KLIPBANK #
0
5
10
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2015
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2009
2008
2007
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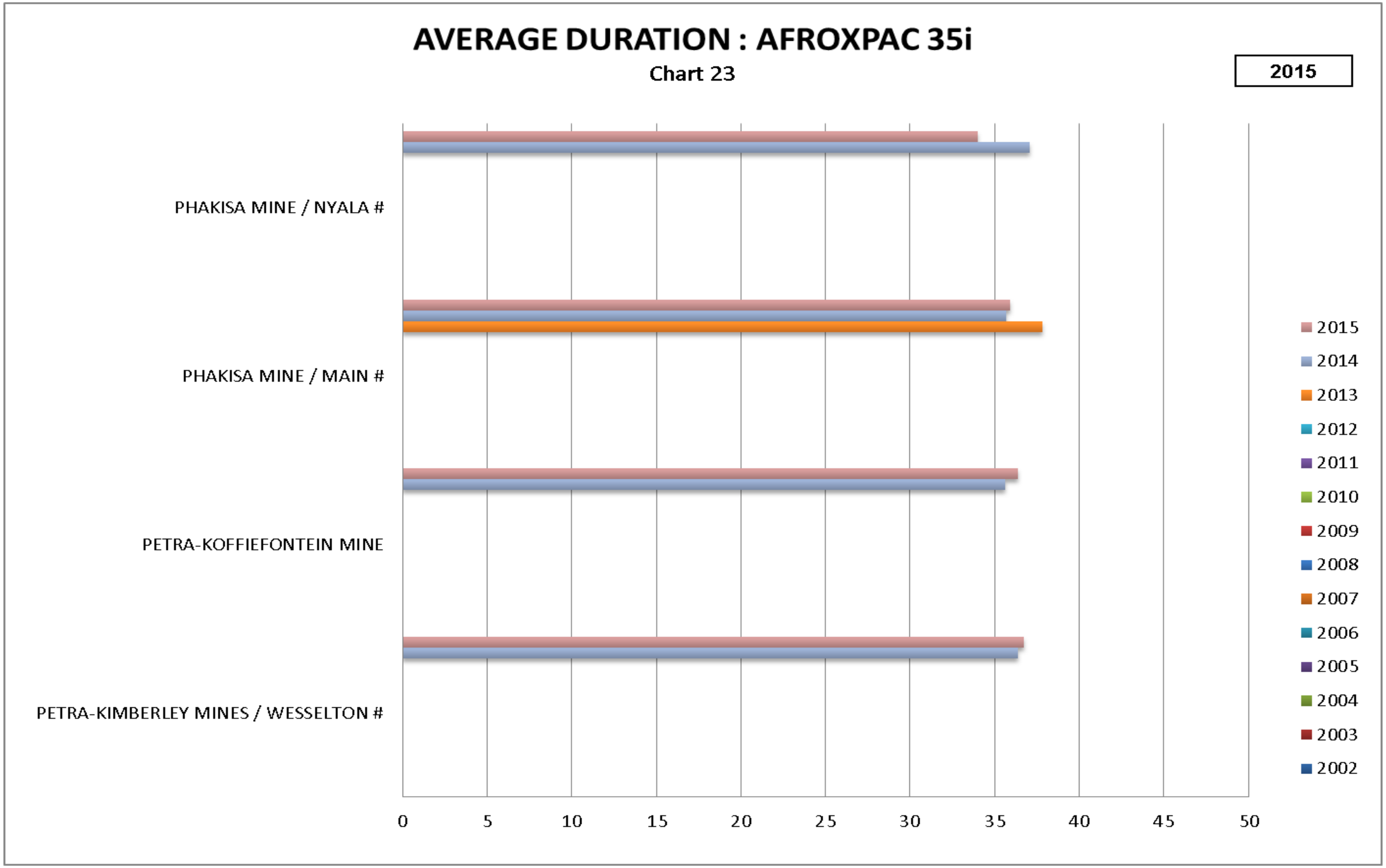

AVERAGE DURATION : AFROXPAC 35i
Chart 23
2015
PHAKISA MINE / NYALA #
PHAKISA MINE / MAIN #
PETRA-KOFFIEFONTEIN MINE
PETRA-KIMBERLEY MINES / WESSELTON #
0
5
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2015
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2010
2009
2008
2007
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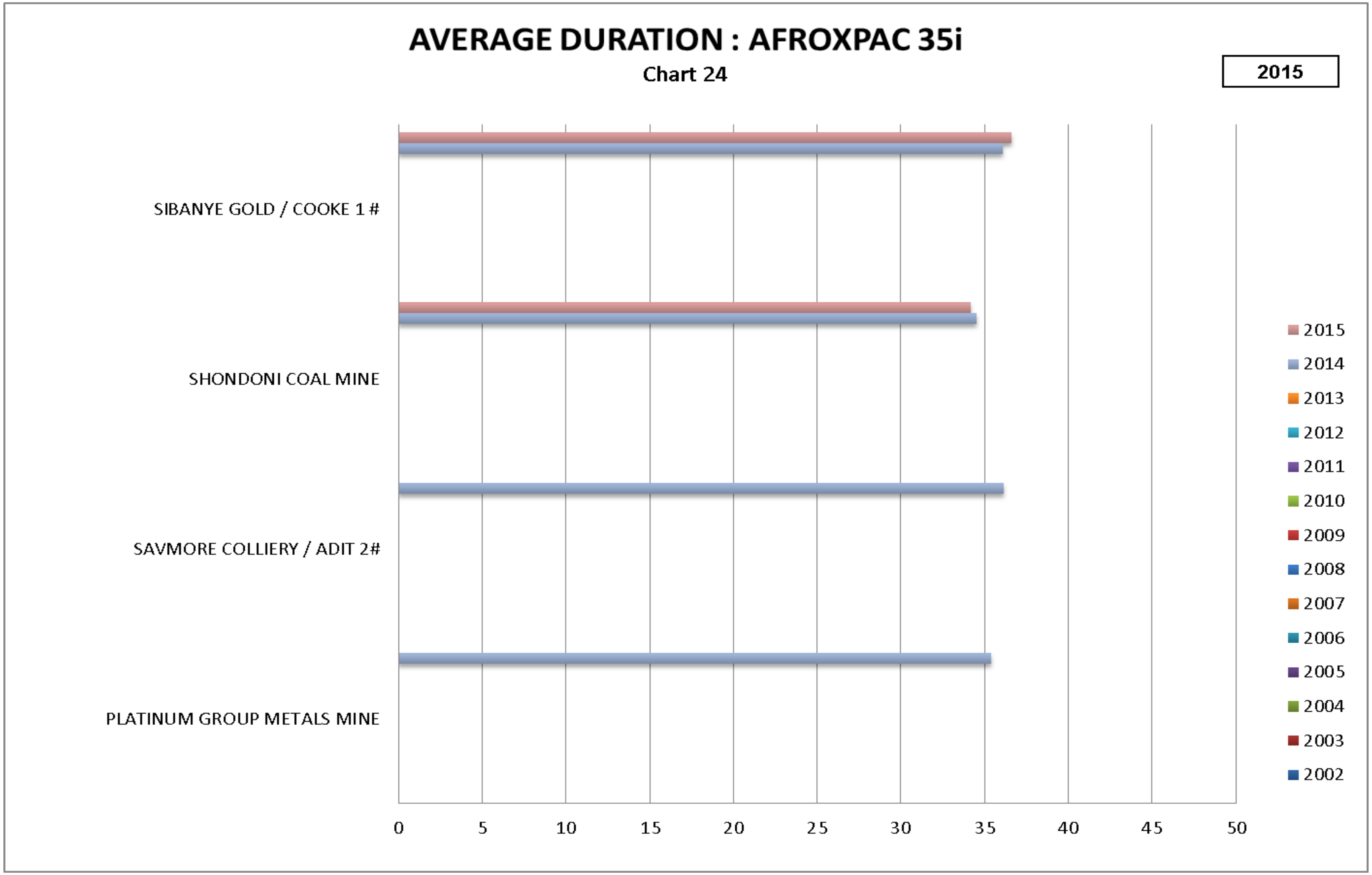
AVERAGE DURATION : AFROXPAC 35i
Chart 24
2015
SIBANYE GOLD / COOKE 1 #
SHONDONI COAL MINE
SAVMORE COLLIERY / ADIT 2#
PLATINUM GROUP METALS MINE
0
5
10
15
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2015
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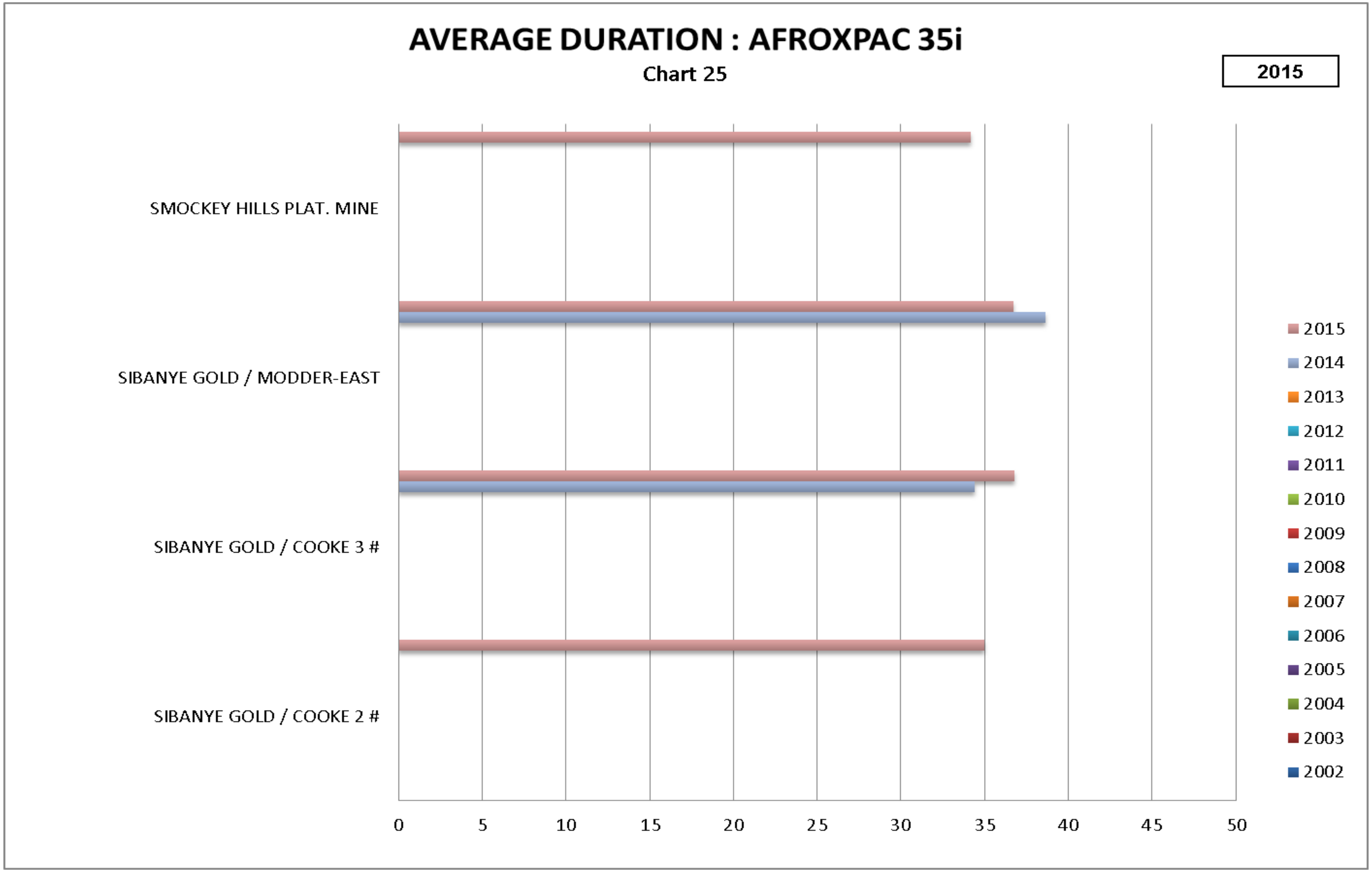
AVERAGE DURATION : AFROXPAC 35i
Chart 25
2015
SMOCKEY HILLS PLAT. MINE
SIBANYE GOLD / MODDER-EAST
SIBANYE GOLD / COOKE 3 #
SIBANYE GOLD / COOKE 2 #
0
5
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2015
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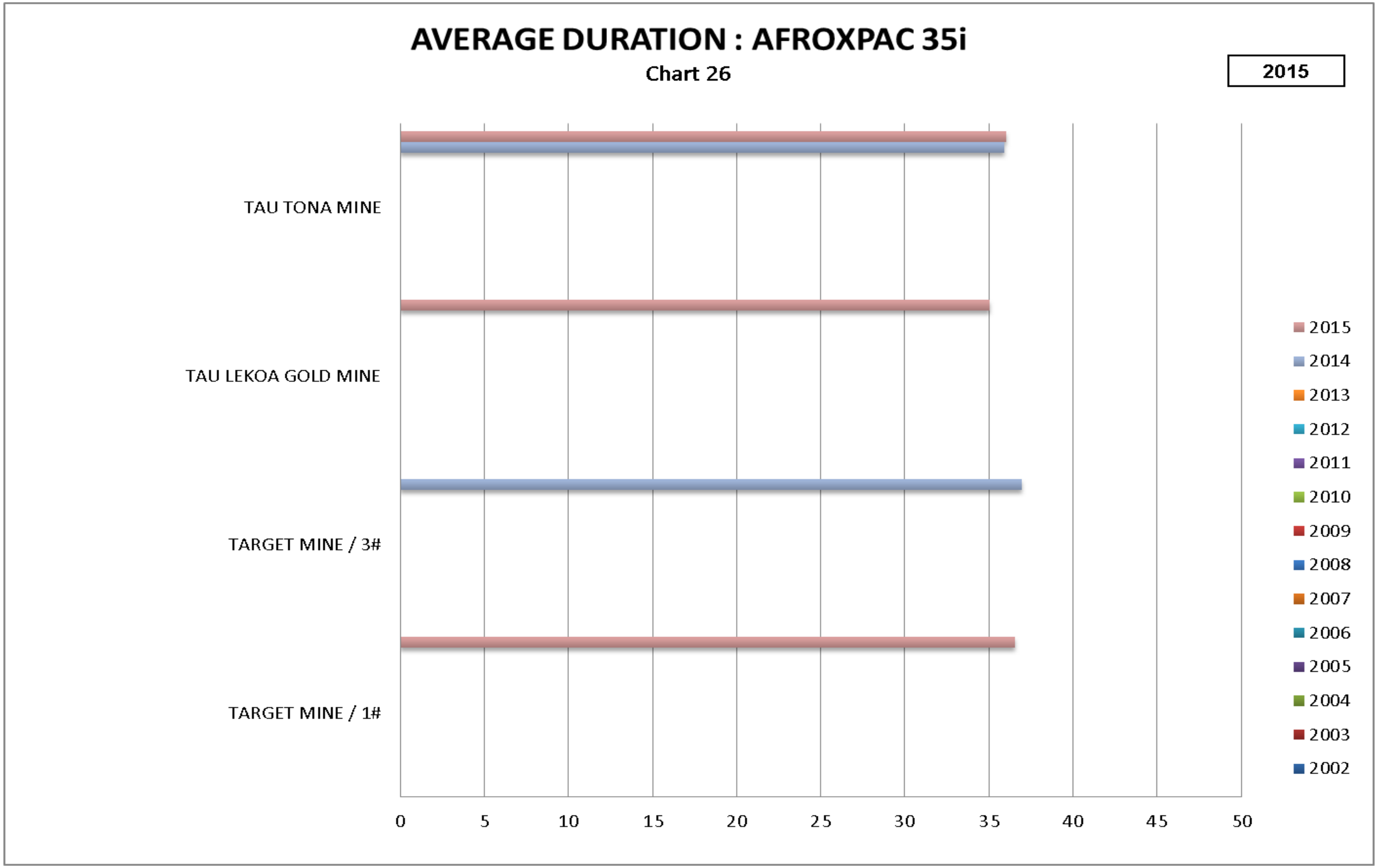
AVERAGE DURATION : AFROXPAC 35i
Chart 26
2015
TAU TONA MINE
TAU LEKOA GOLD MINE
TARGET MINE / 3#
TARGET MINE / 1#
0
5
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15
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25
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2015
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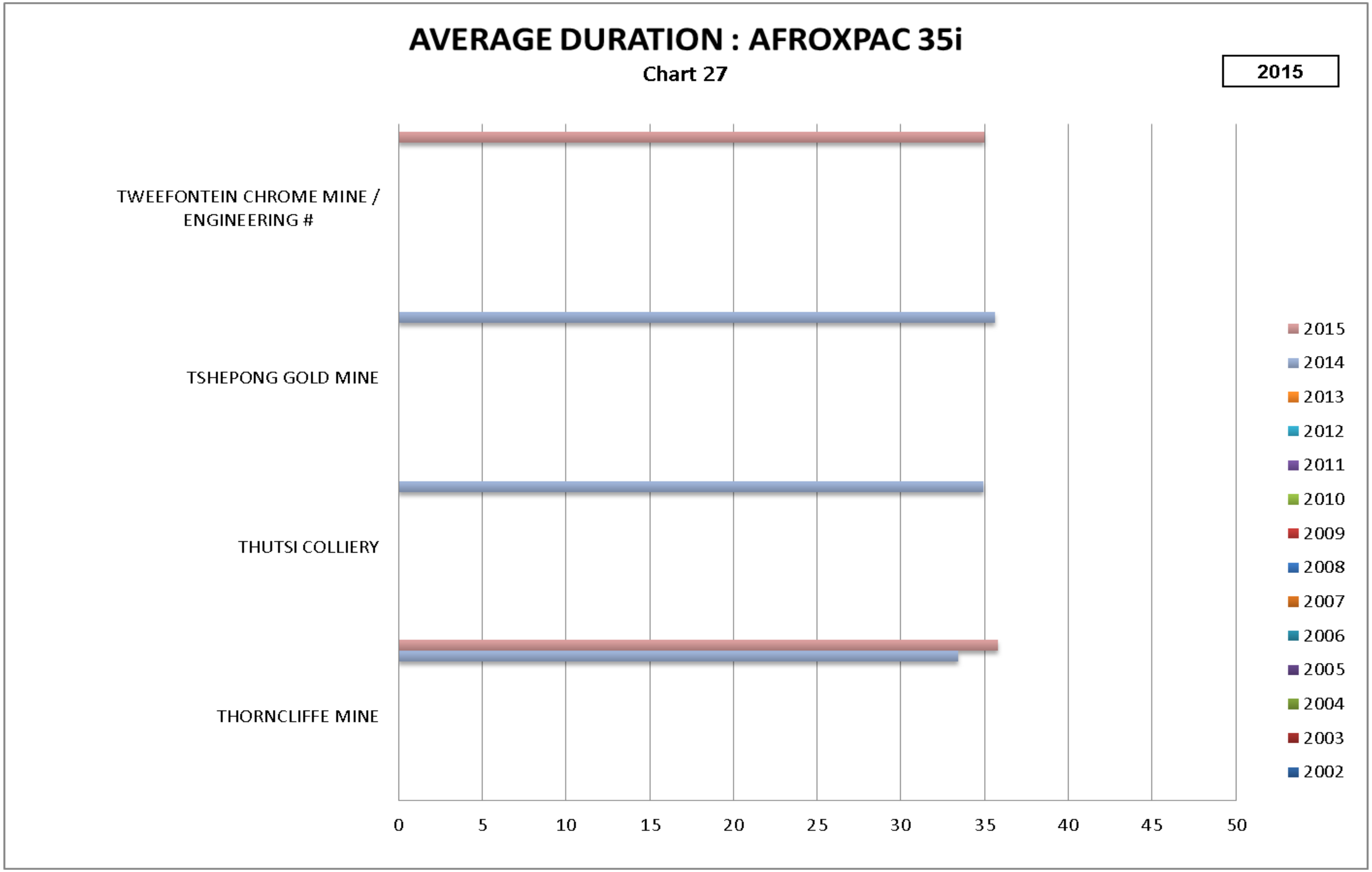
AVERAGE DURATION : AFROXPAC 35i
Chart 27
2015
TWEEFONTEIN CHROME MINE / ENGINEERING #
TSHEPONG GOLD MINE
THUTSI COLLIERY
THORNCLIFFE MINE
0
5
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2015
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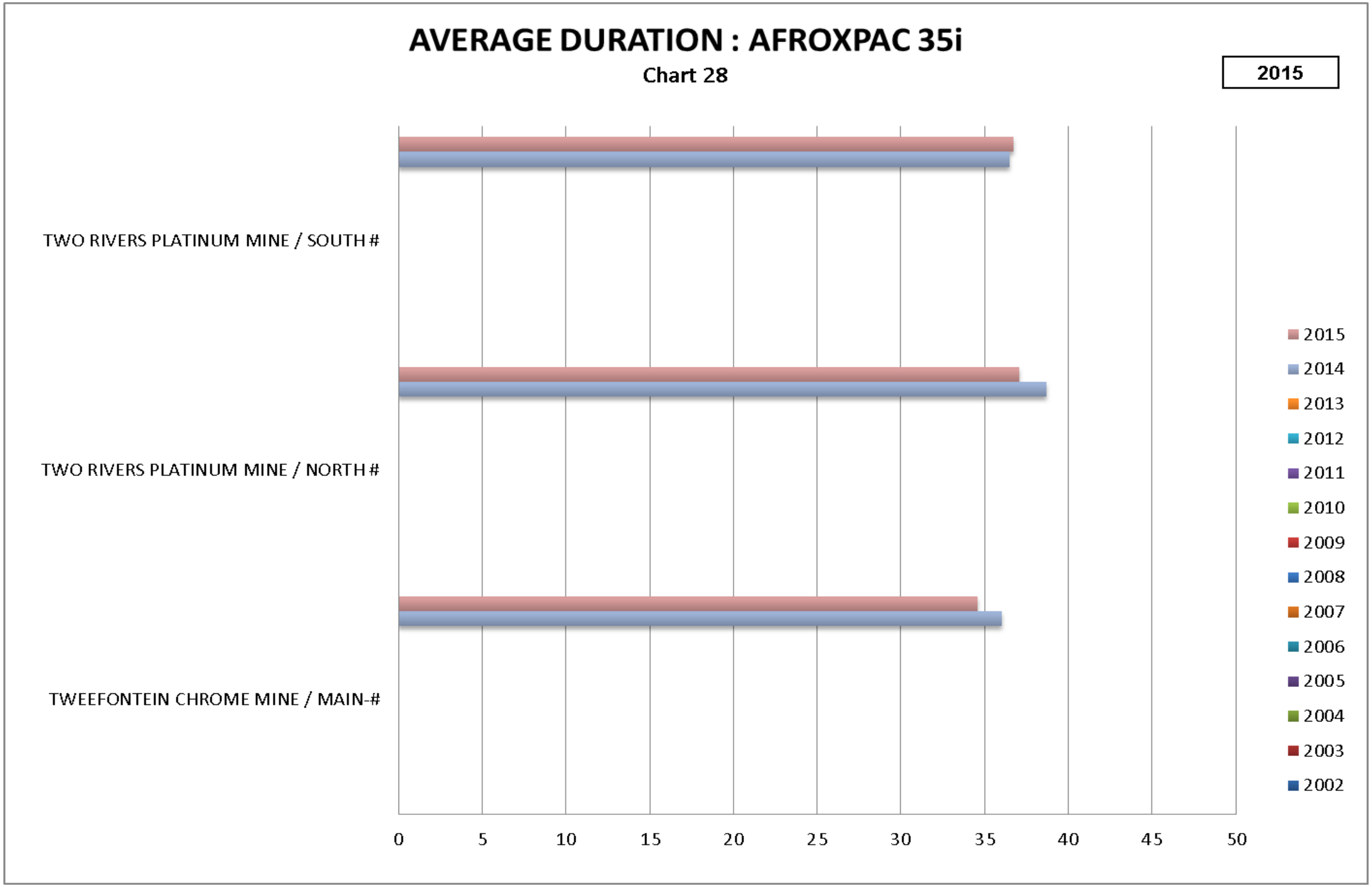
AVERAGE DURATION : AFROXPAC 35i
Chart 28
2015
TWO RIVERS PLATINUM MINE / SOUTH #
TWO RIVERS PLATINUM MINE / NORTH #
TWEEFONTEIN CHROME MINE / MAIN-#
0
5
10
15
20
25
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2015
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2013
2012
2011
2010
2009
2008
2007
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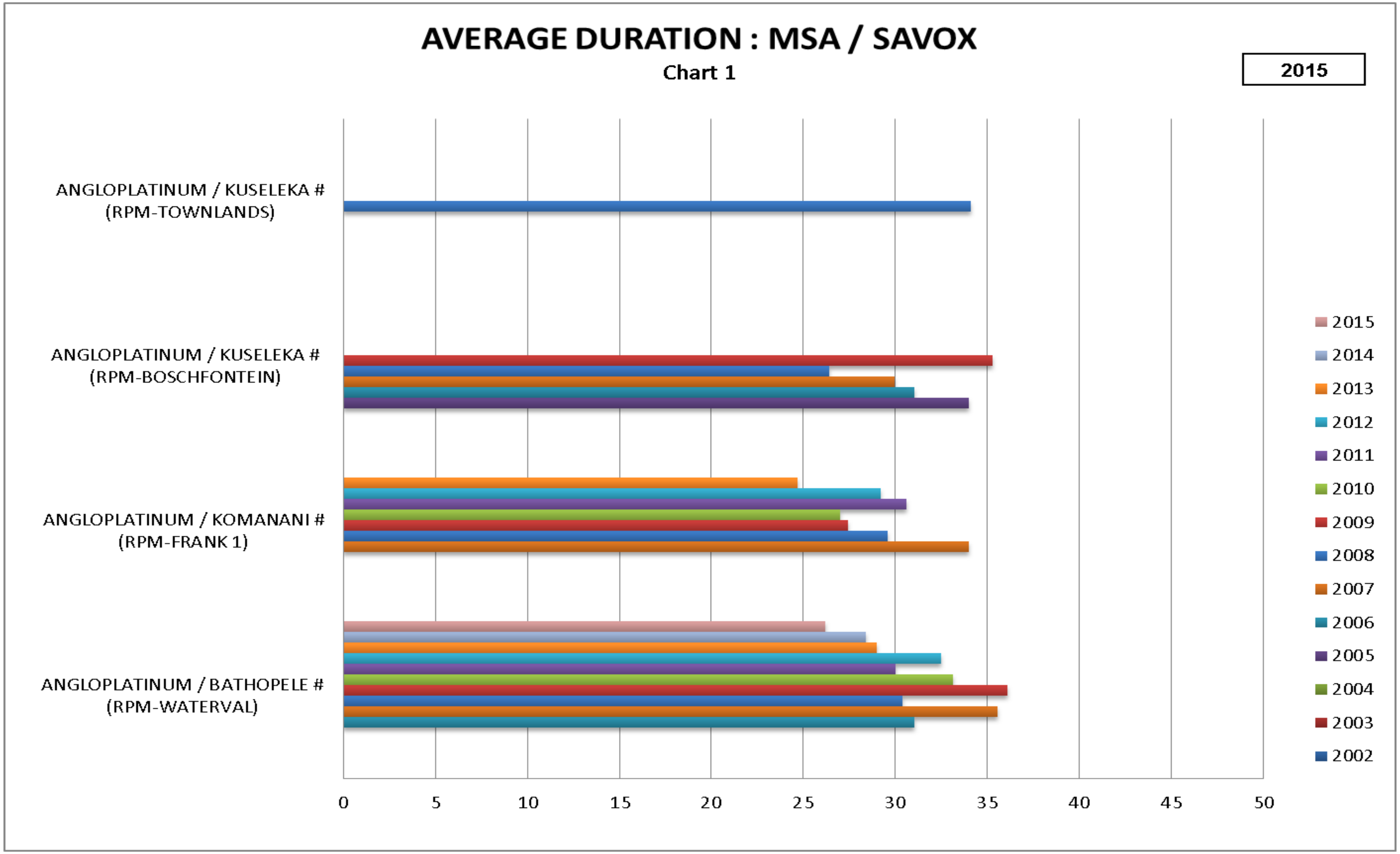
AVERAGE DURATION : MSA / SAVOX
Chart 1
2015
ANGLOPLATINUM / KUSELEKA #
(RPM-TOWNLANDS)
ANGLOPLATINUM / KUSELEKA #
(RPM-BOSCHFONTEIN)
ANGLOPLATINUM / KOMANANI #
(RPM-FRANK 1)
ANGLOPLATINUM / BATHOPELE #
(RPM-WATERVAL)
0
5
10
15
20
25
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35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
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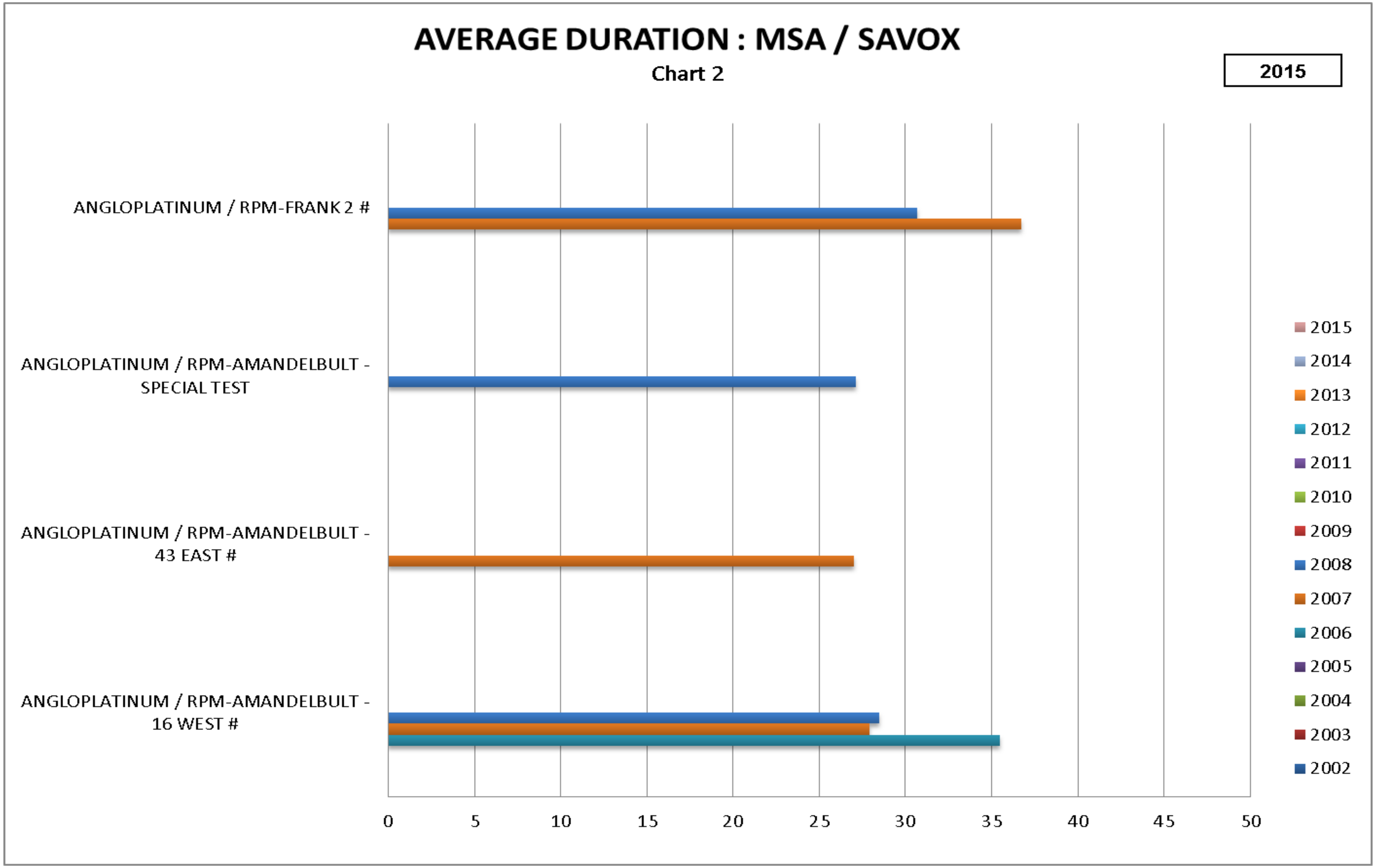
AVERAGE DURATION : MSA / SAVOX
Chart 2
2015
ANGLOPLATINUM / RPM-FRANK 2 #
ANGLOPLATINUM / RPM-AMANDELBULT - SPECIAL TEST
ANGLOPLATINUM / RPM-AMANDELBULT - 43 EAST #
ANGLOPLATINUM / RPM-AMANDELBULT - 16 WEST #
0
5
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45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
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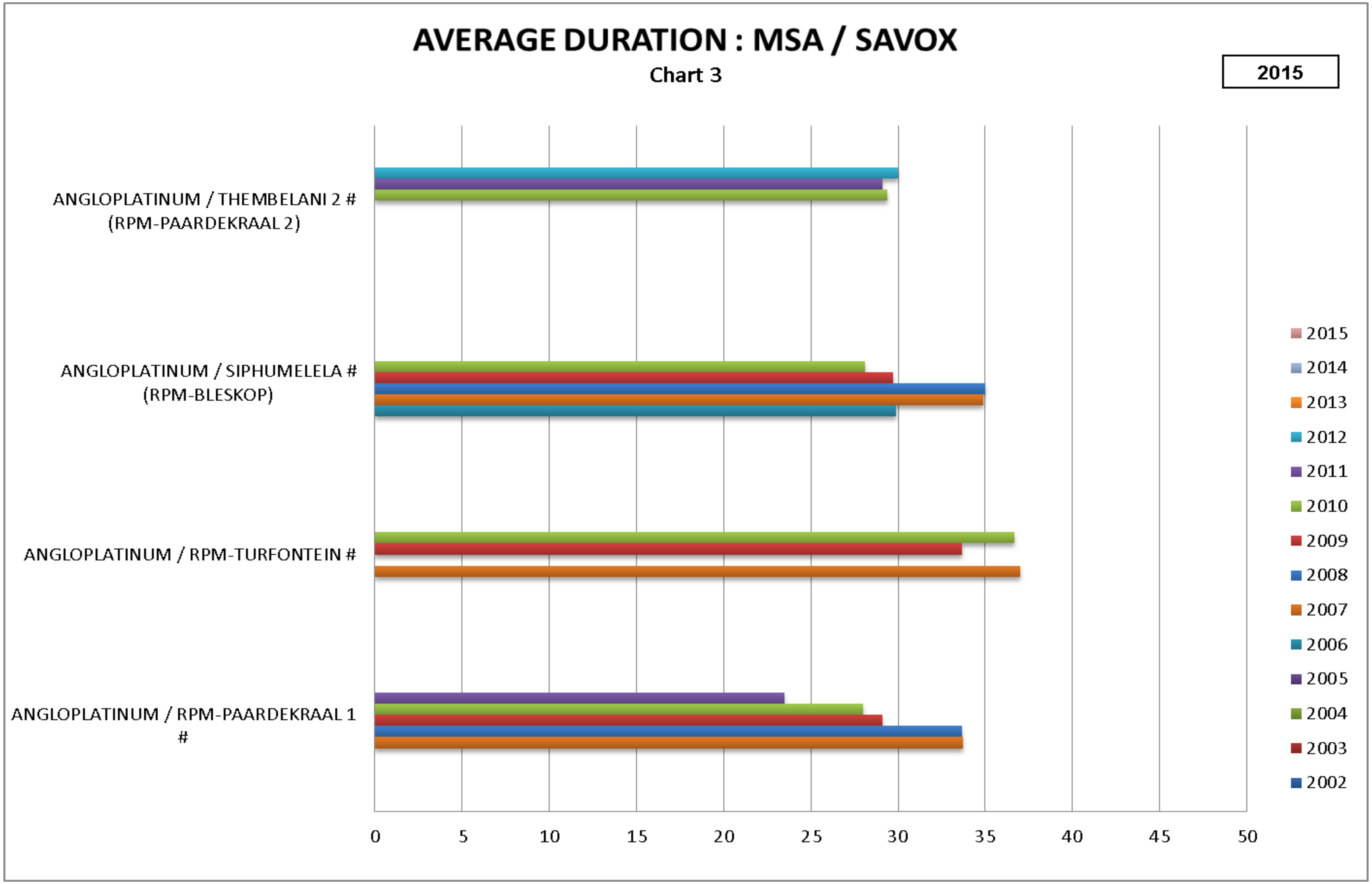
AVERAGE DURATION : MSA / SAVOX
Chart 3
2015
ANGLOPLATINUM / THEMBELANI 2 # (RPM-PAARDEKRAAL 2)
ANGLOPLATINUM / SIPHUMELELA # (RPM-BLESKOP)
ANGLOPLATINUM / RPM-TURFONTEIN #
ANGLOPLATINUM / RPM-PAARDEKRAAL 1 #
0
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2015
2014
2013
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2009
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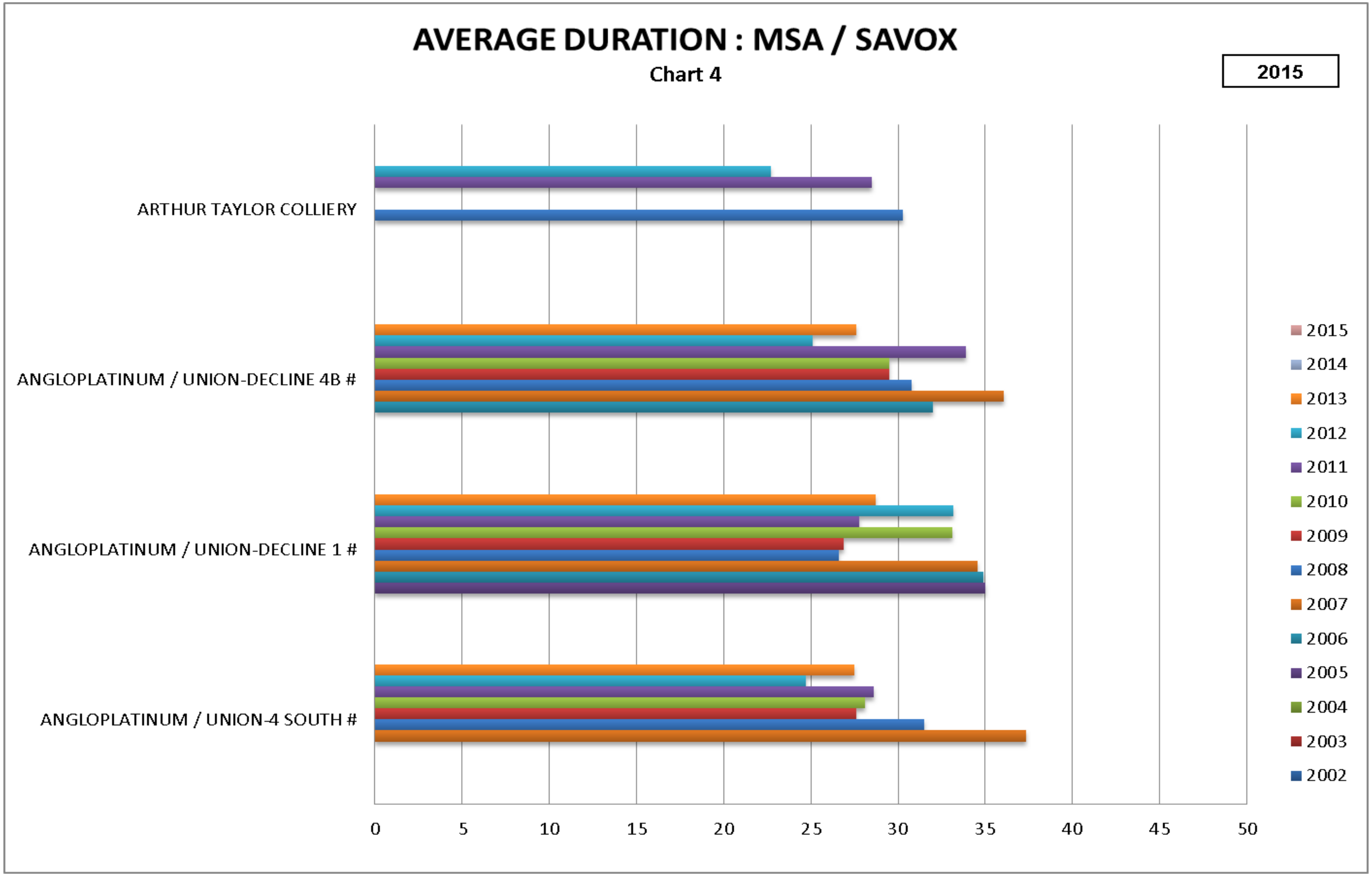
AVERAGE DURATION : MSA / SAVOX
Chart 4
2015
ARTHUR TAYLOR COLLIERY
ANGLOPLATINUM / UNION-DECLINE 4B #
ANGLOPLATINUM / UNION-DECLINE 1 #
ANGLOPLATINUM / UNION-4 SOUTH #
0
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2015
2014
2013
2012
2011
2010
2009
2008
2007
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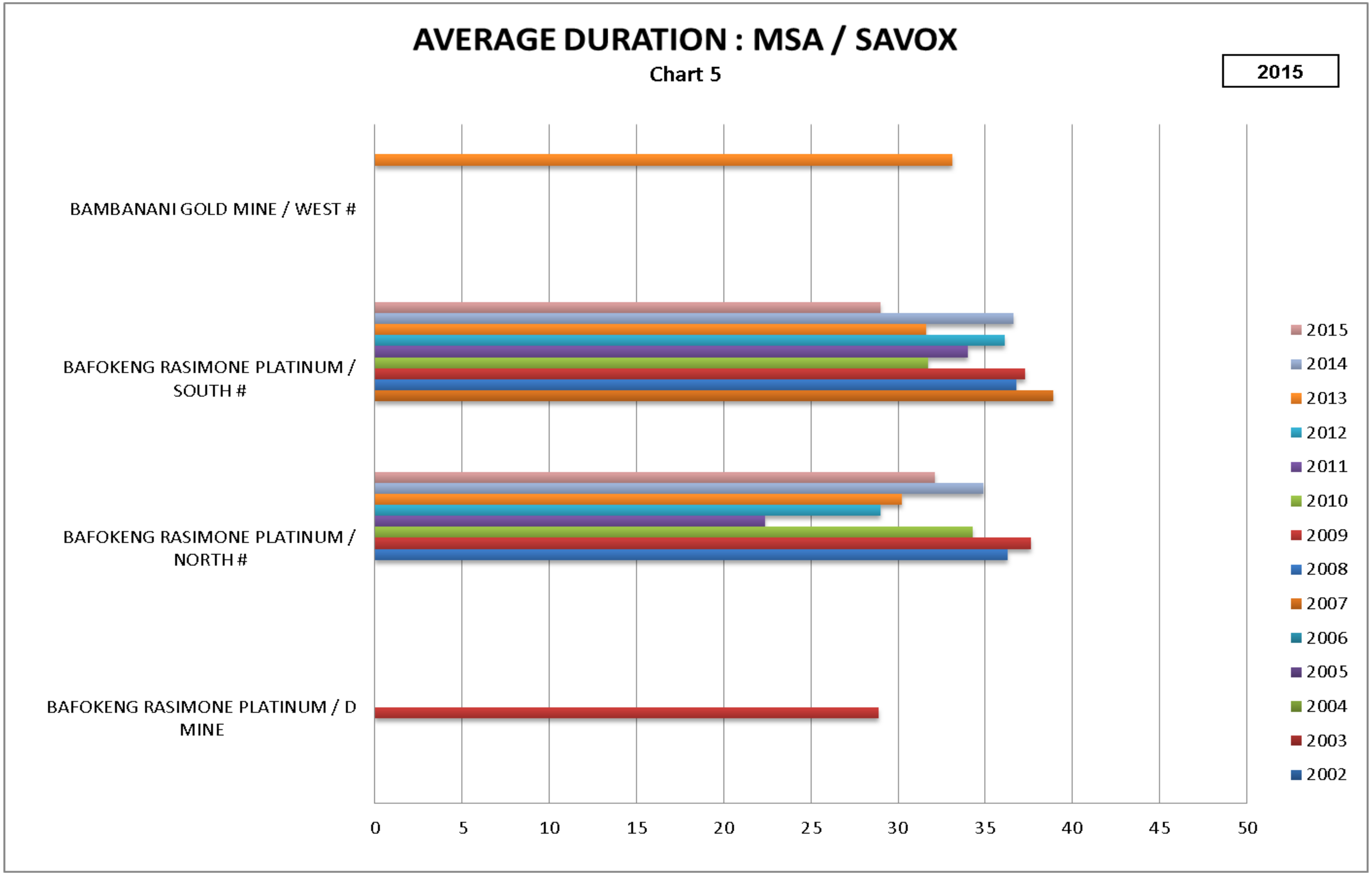

AVERAGE DURATION : MSA / SAVOX
Chart 5
2015
BAMBANANI GOLD MINE / WEST #
BAFOKENG RASIMONE PLATINUM / SOUTH #
BAFOKENG RASIMONE PLATINUM / NORTH #
BAFOKENG RASIMONE PLATINUM / D MINE
0
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2011
2010
2009
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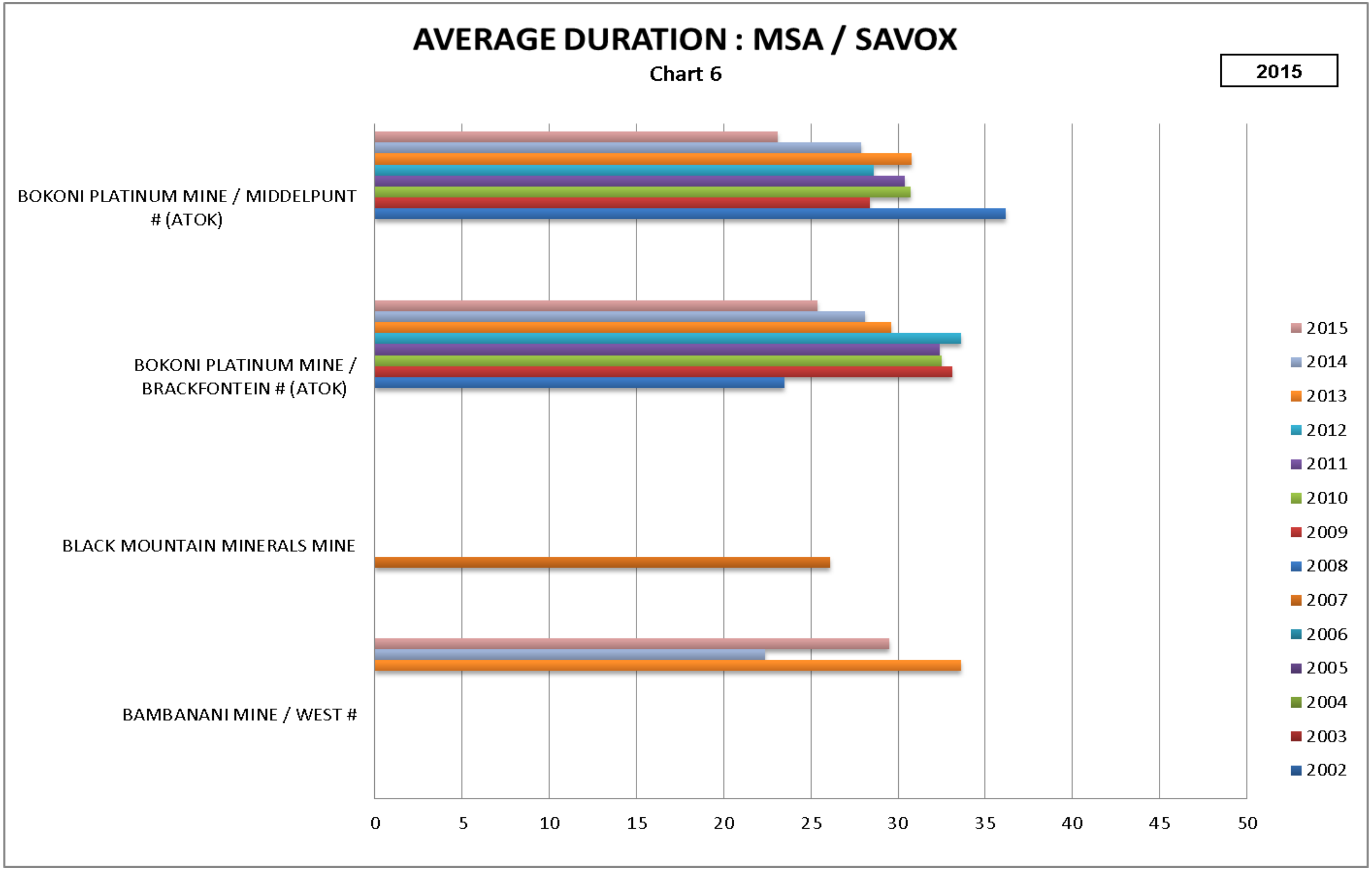
AVERAGE DURATION : MSA / SAVOX
Chart 6
2015
BOKONI PLATINUM MINE / MIDDELPUNT # (ATOK)
BOKONI PLATINUM MINE / BRACKFONTEIN # (ATOK)
BLACK MOUNTAIN MINERALS MINE
BAMBANANI MINE / WEST #
0
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2015
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2004
2003
2002


AVERAGE DURATION : MSA / SAVOX
Chart 7
2015
EAST PLATS / VERTICAL #
EAST PLATS / MARULABULT #
DILOKONG MINE
DE BEERS DIAMOND MINE / VENITIA #
0
5
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35
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45
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2015
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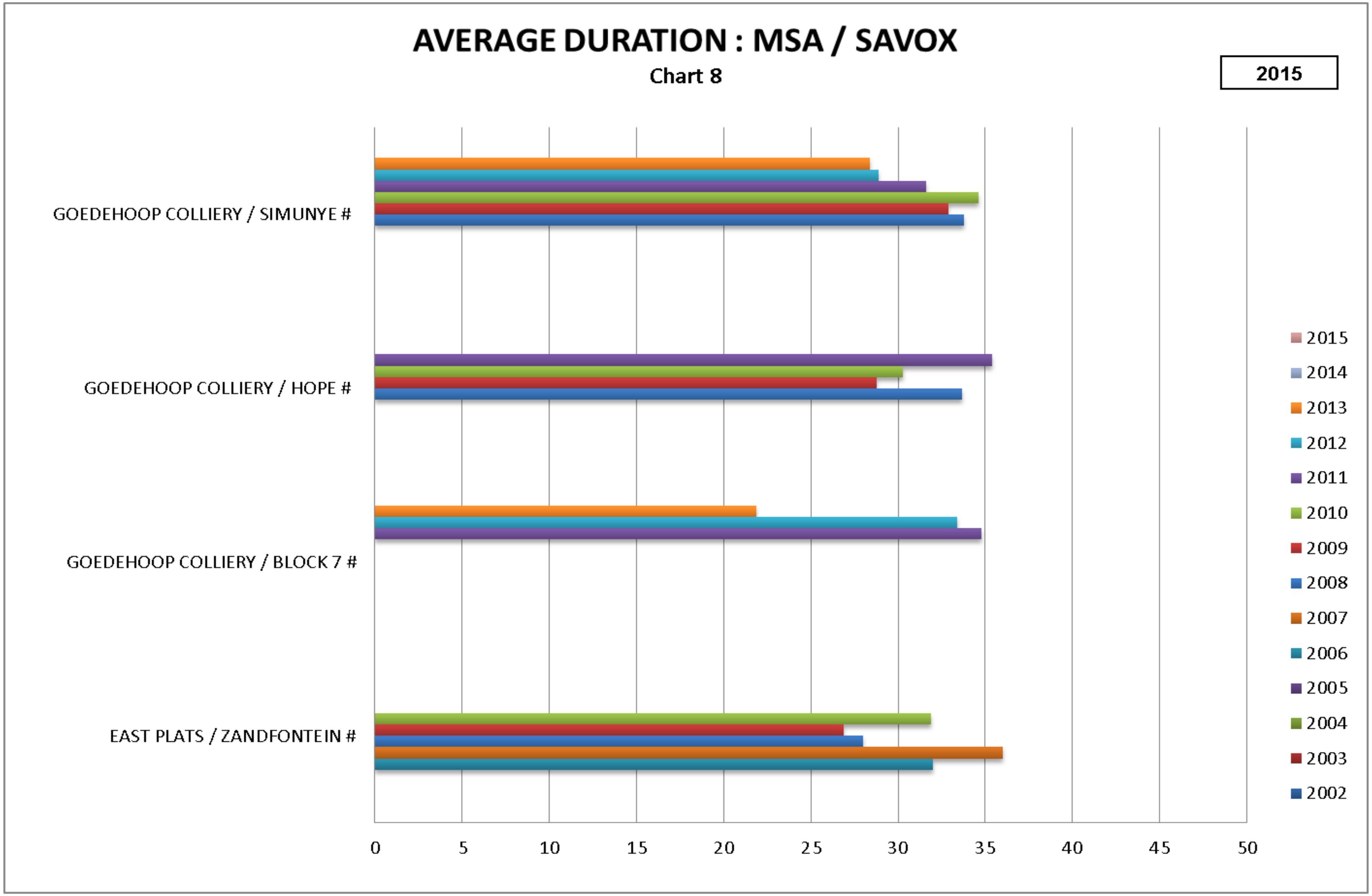
AVERAGE DURATION : MSA / SAVOX
Chart 8
2015
GOEDEHOOP COLLIERY / SIMUNYE #
GOEDEHOOP COLLIERY / HOPE #
GOEDEHOOP COLLIERY / BLOCK 7 #
EAST PLATS / ZANDFONTEIN #
0
5
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2014
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2012
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2009
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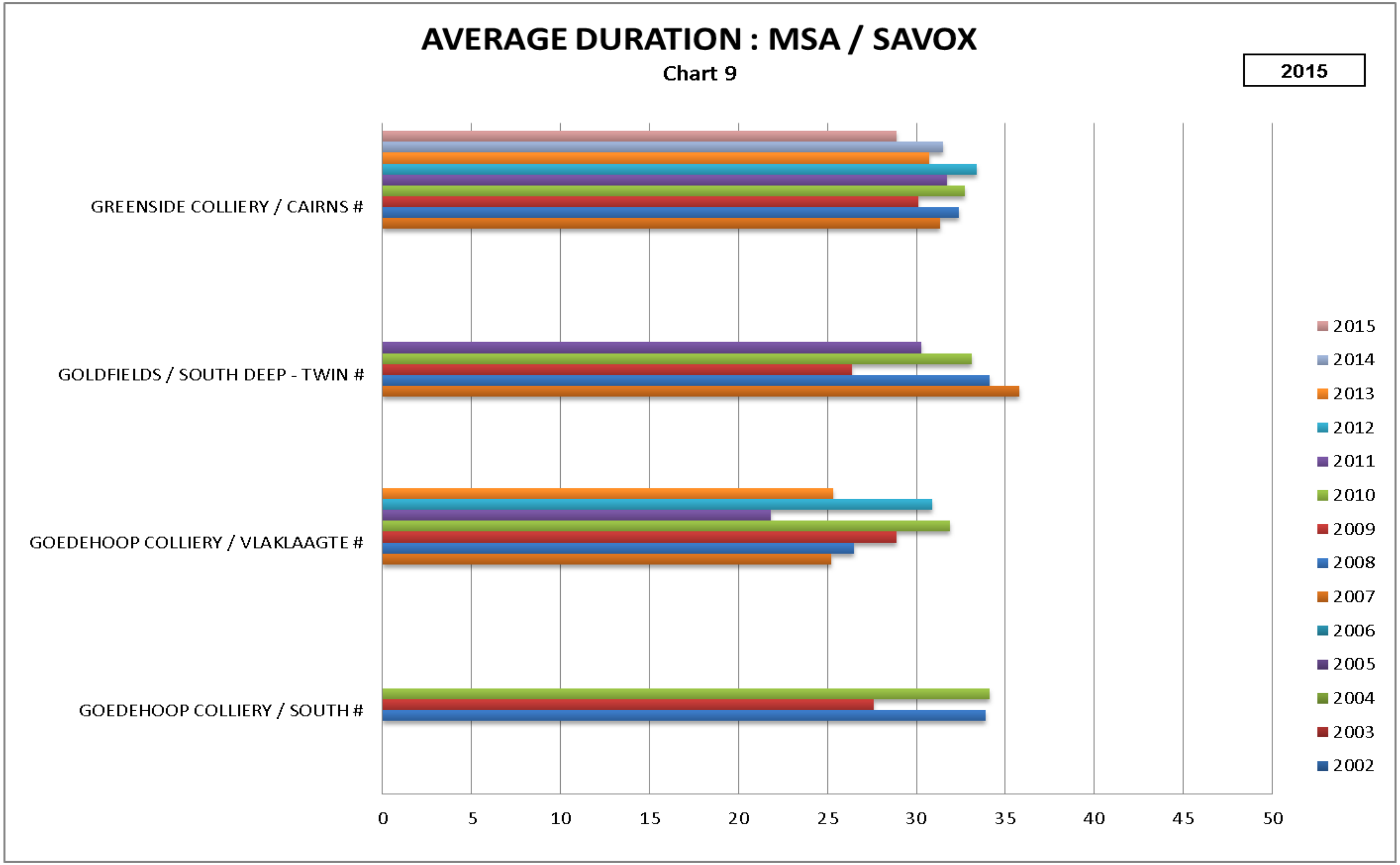
AVERAGE DURATION : MSA / SAVOX
Chart 9
2015
GREENSIDE COLLIERY / CAIRNS #
GOLDFIELDS / SOUTH DEEP - TWIN #
GOEDEHOOP COLLIERY / VLAKLAAGTE #
GOEDEHOOP COLLIERY / SOUTH #
0
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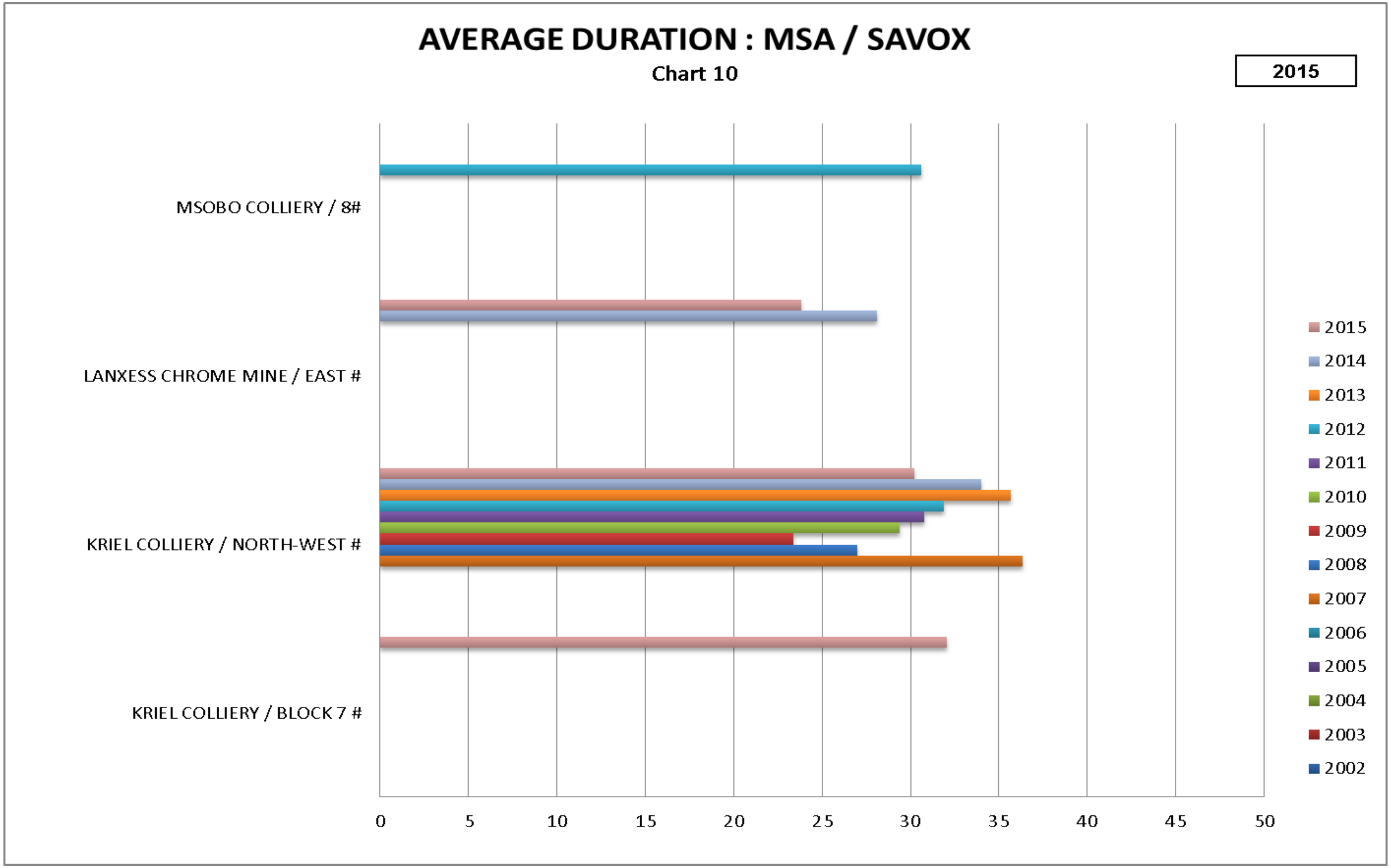
AVERAGE DURATION : MSA / SAVOX
Chart 10
2015
MSOBO COLLIERY / 8#
LANXESS CHROME MINE / EAST #
KRIEL COLLIERY / NORTH-WEST #
KRIEL COLLIERY / BLOCK 7 #
0
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2013
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2011
2010
2009
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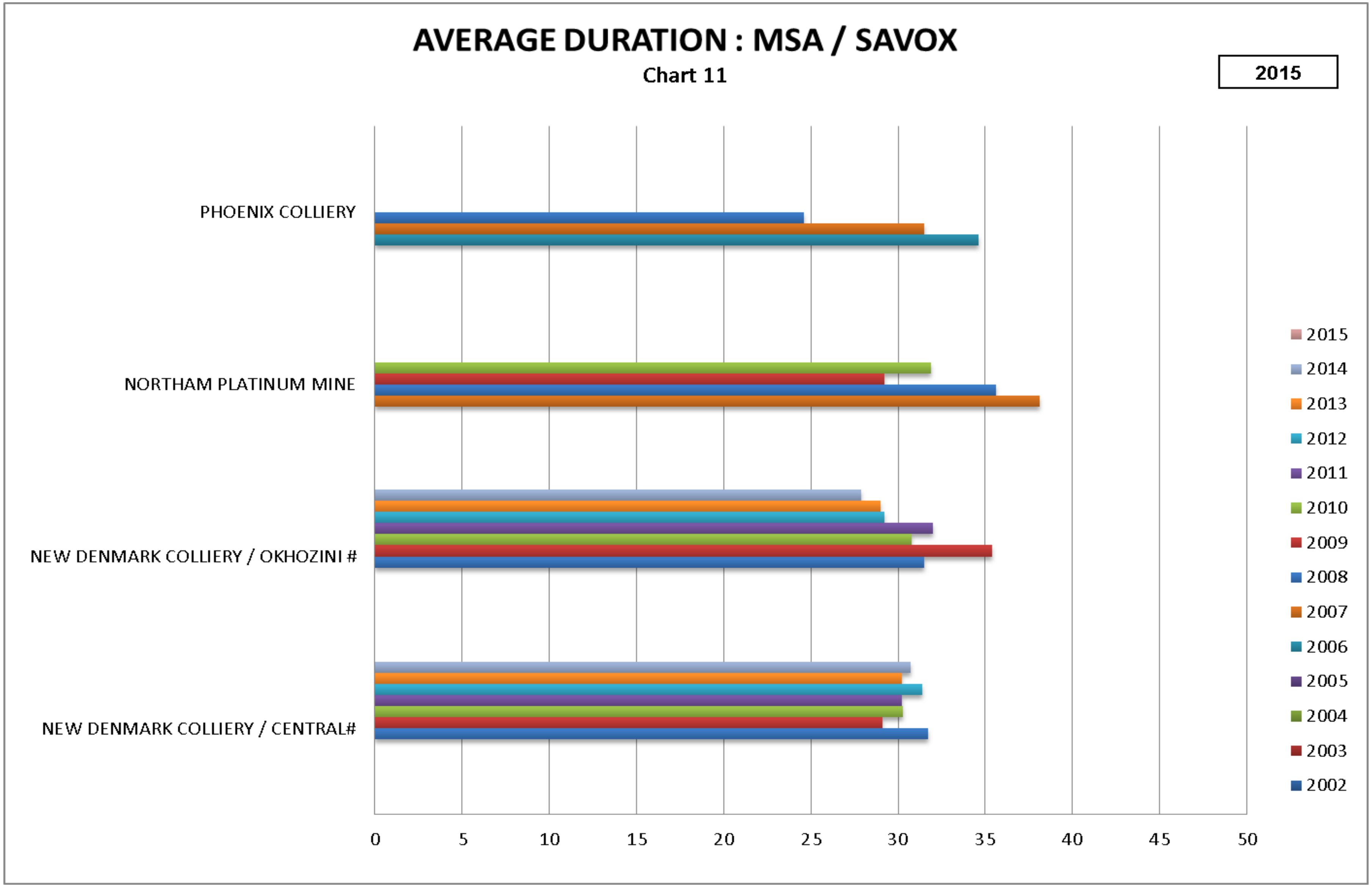
AVERAGE DURATION : MSA / SAVOX
Chart 11
2015
PHOENIX COLLIERY
NORTHAM PLATINUM MINE
NEW DENMARK COLLIERY / OKHOZINI #
NEW DENMARK COLLIERY / CENTRAL#
0
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2015
2014
2013
2012
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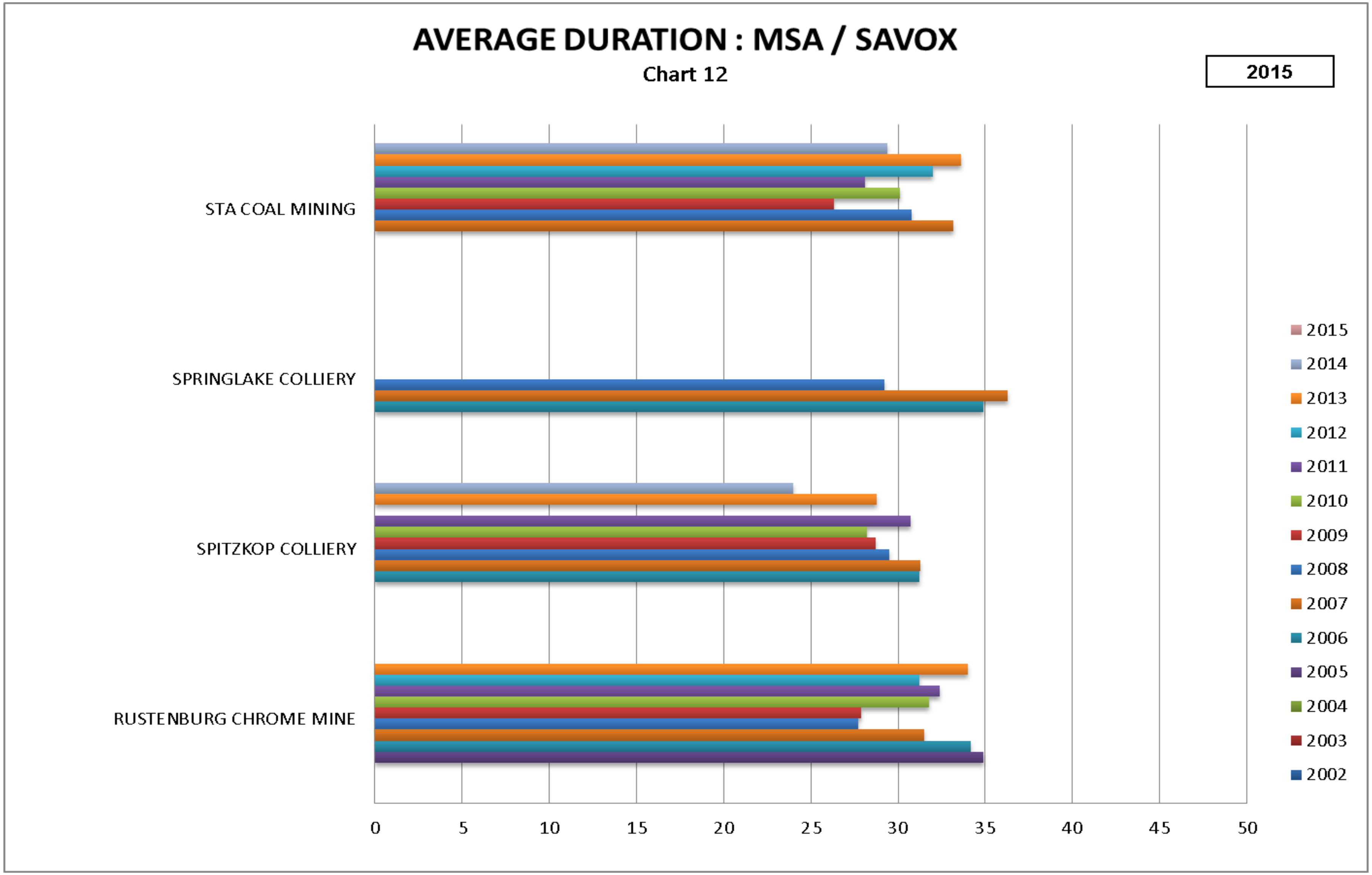
AVERAGE DURATION : MSA / SAVOX
Chart 12
2015
STA COAL MINING
SPRINGLAKE COLLIERY
SPITZKOP COLLIERY
RUSTENBURG CHROME MINE
0
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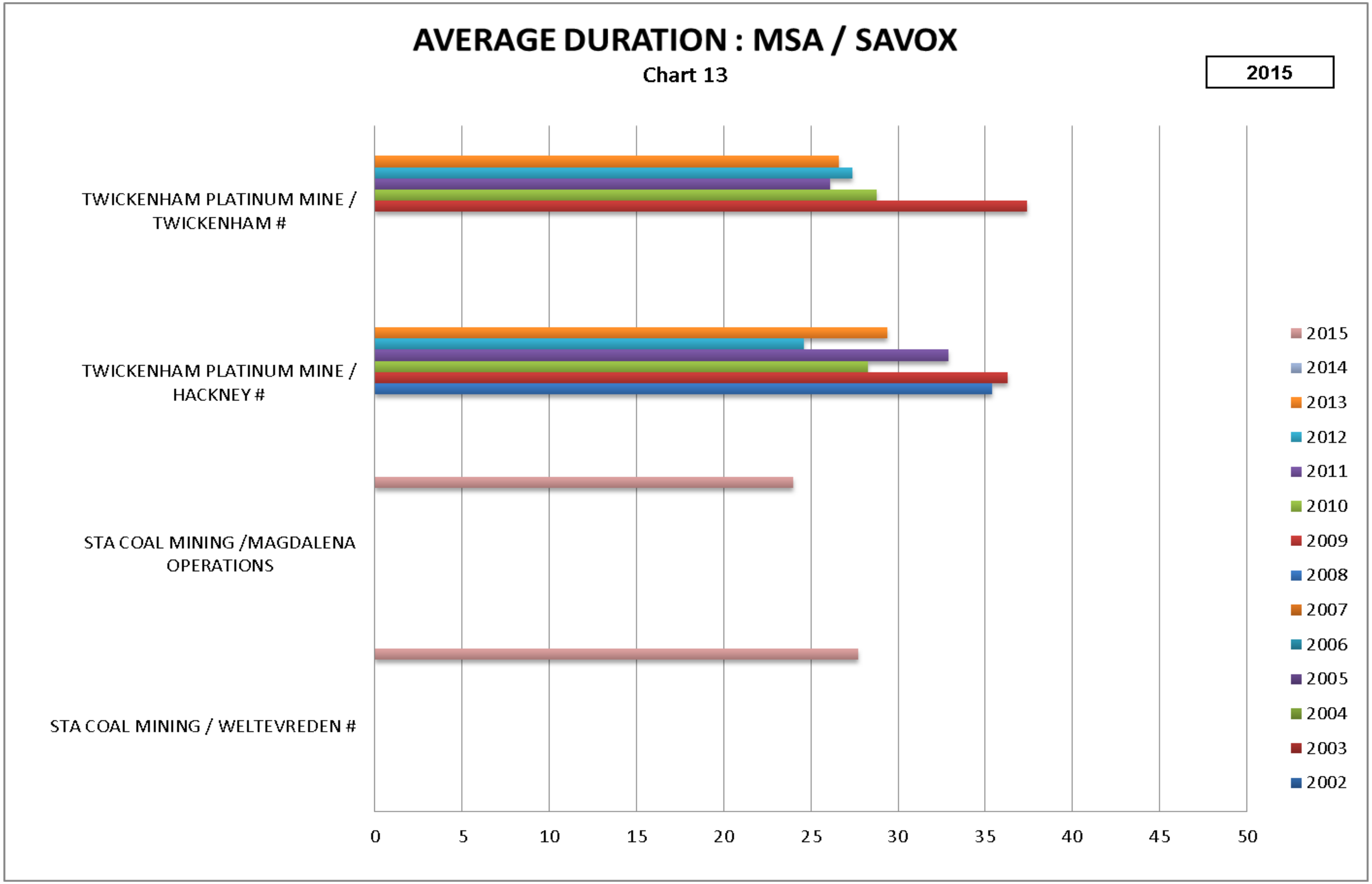
AVERAGE DURATION : MSA / SAVOX
Chart 13
2015
TWICKENHAM PLATINUM MINE / TWICKENHAM #
TWICKENHAM PLATINUM MINE / HACKNEY #
STA COAL MINING /MAGDALENA OPERATIONS
STA COAL MINING / WELTEVREDEN #
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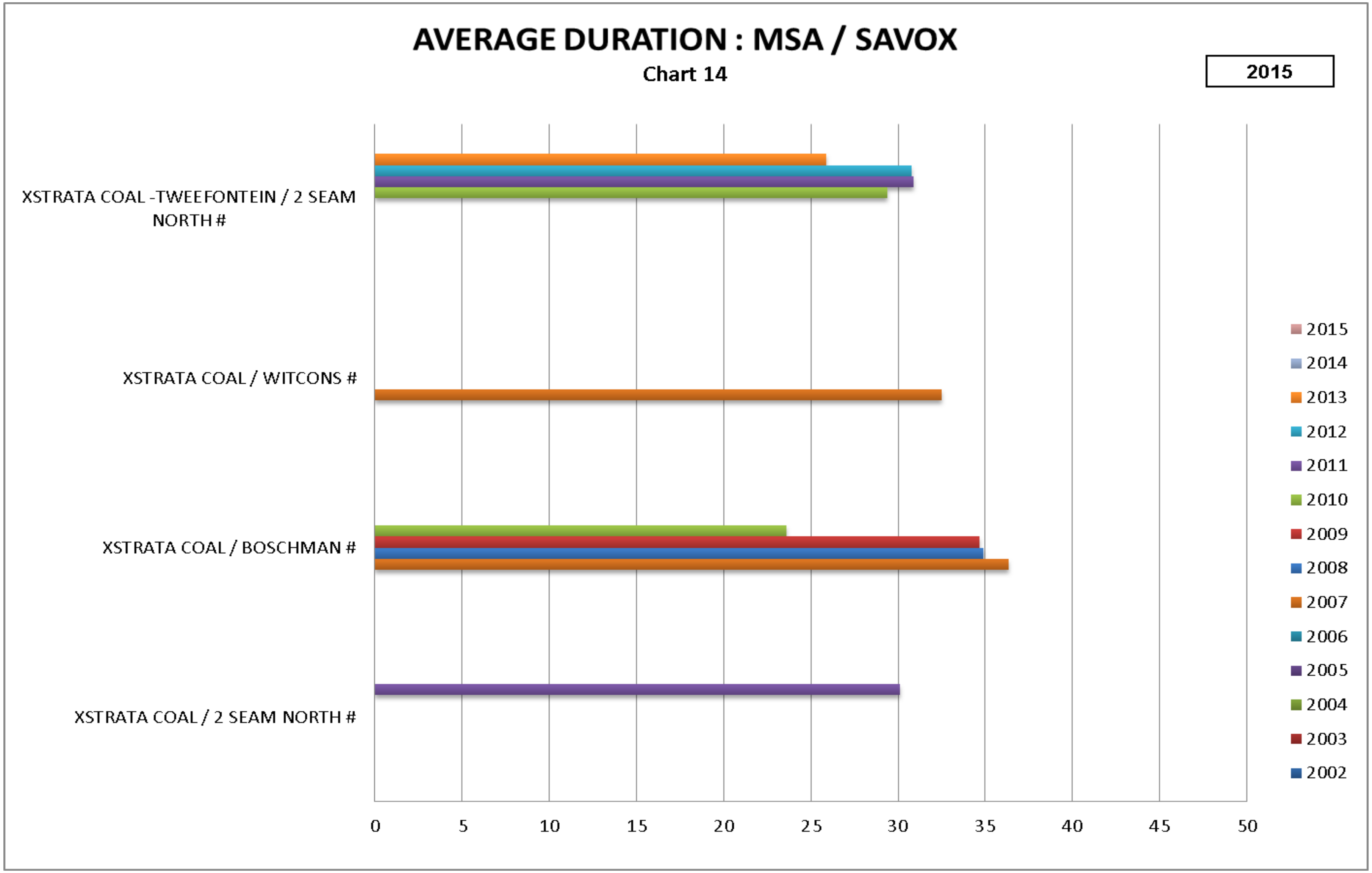
AVERAGE DURATION : MSA / SAVOX
Chart 14
2015
XSTRATA COAL -TWEEFONTEIN / 2 SEAM NORTH #
XSTRATA COAL / WITCONS #
XSTRATA COAL / BOSCHMAN #
XSTRATA COAL / 2 SEAM NORTH #
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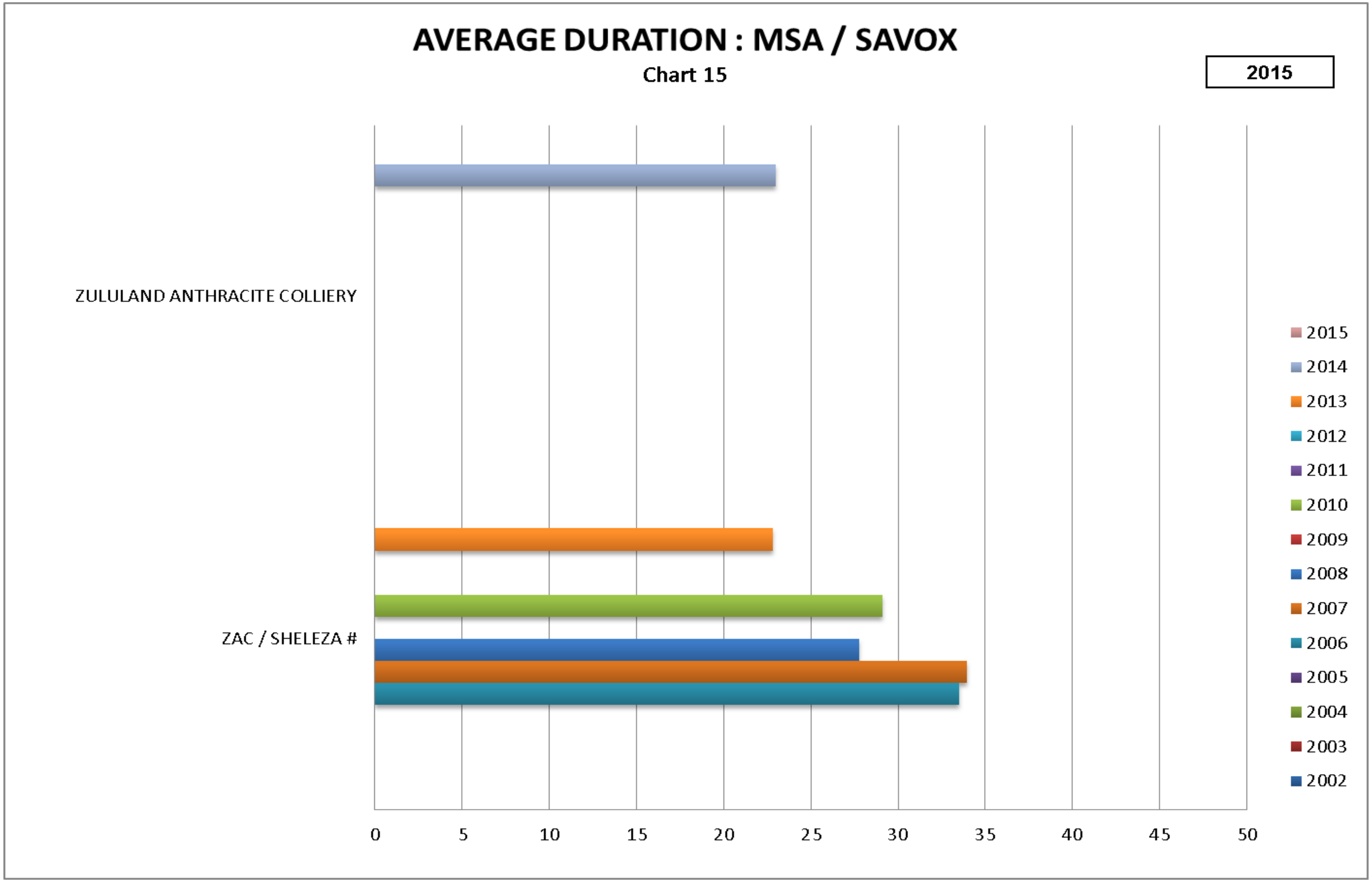

AVERAGE DURATION : MSA / SAVOX
Chart 15
2015
ZULULAND ANTHRACITE COLLIERY
ZAC / SHELEZA #
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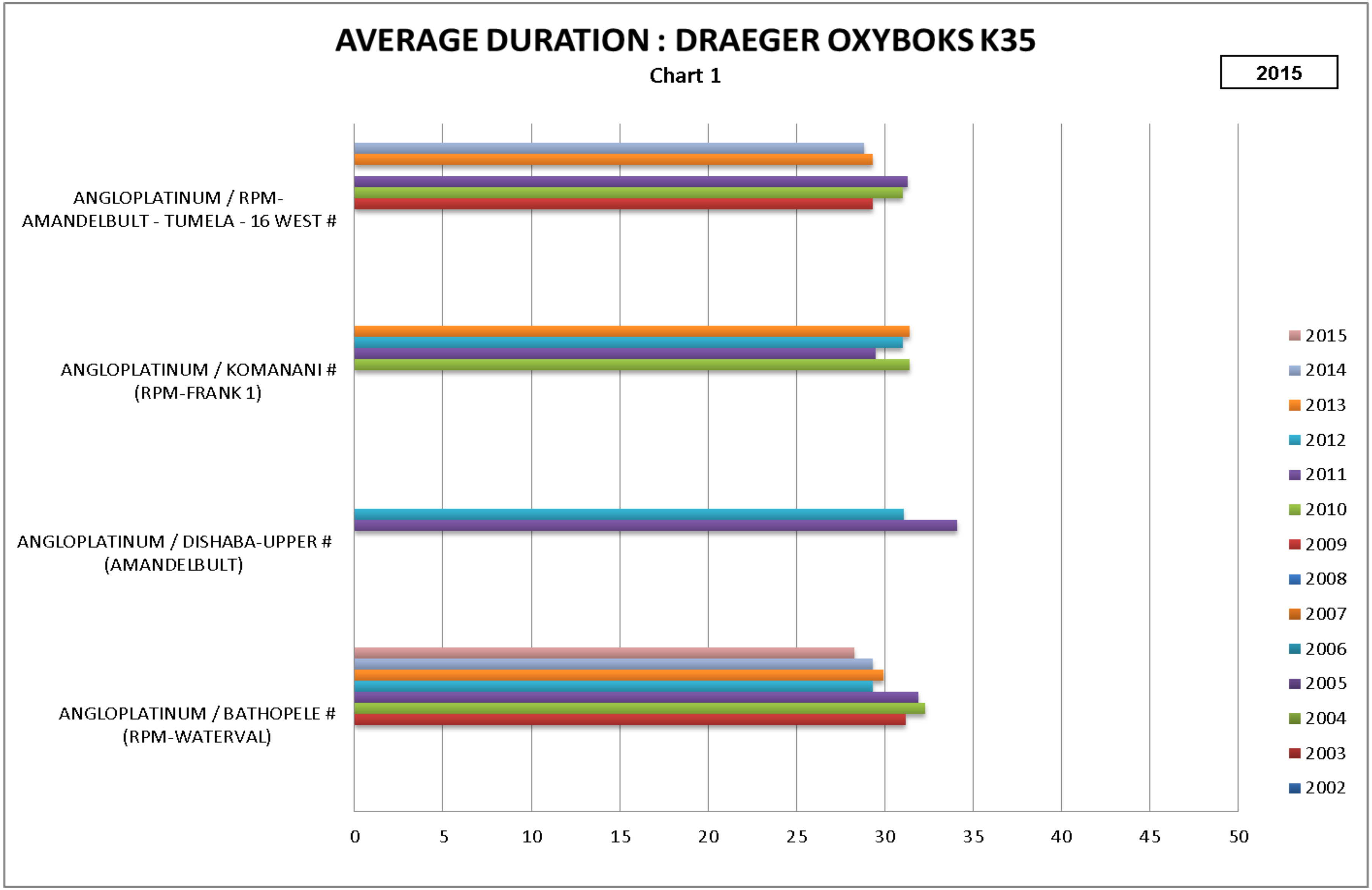
AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 1
2015
ANGLOPLATINUM / RPM-AMANDELBULT - TUMELA - 16 WEST #
ANGLOPLATINUM / KOMANANI # (RPM-FRANK 1)
ANGLOPLATINUM / DISHABA-UPPER # (AMANDELBULT)
ANGLOPLATINUM / BATHOPELE # (RPM-WATERVAL)
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2015
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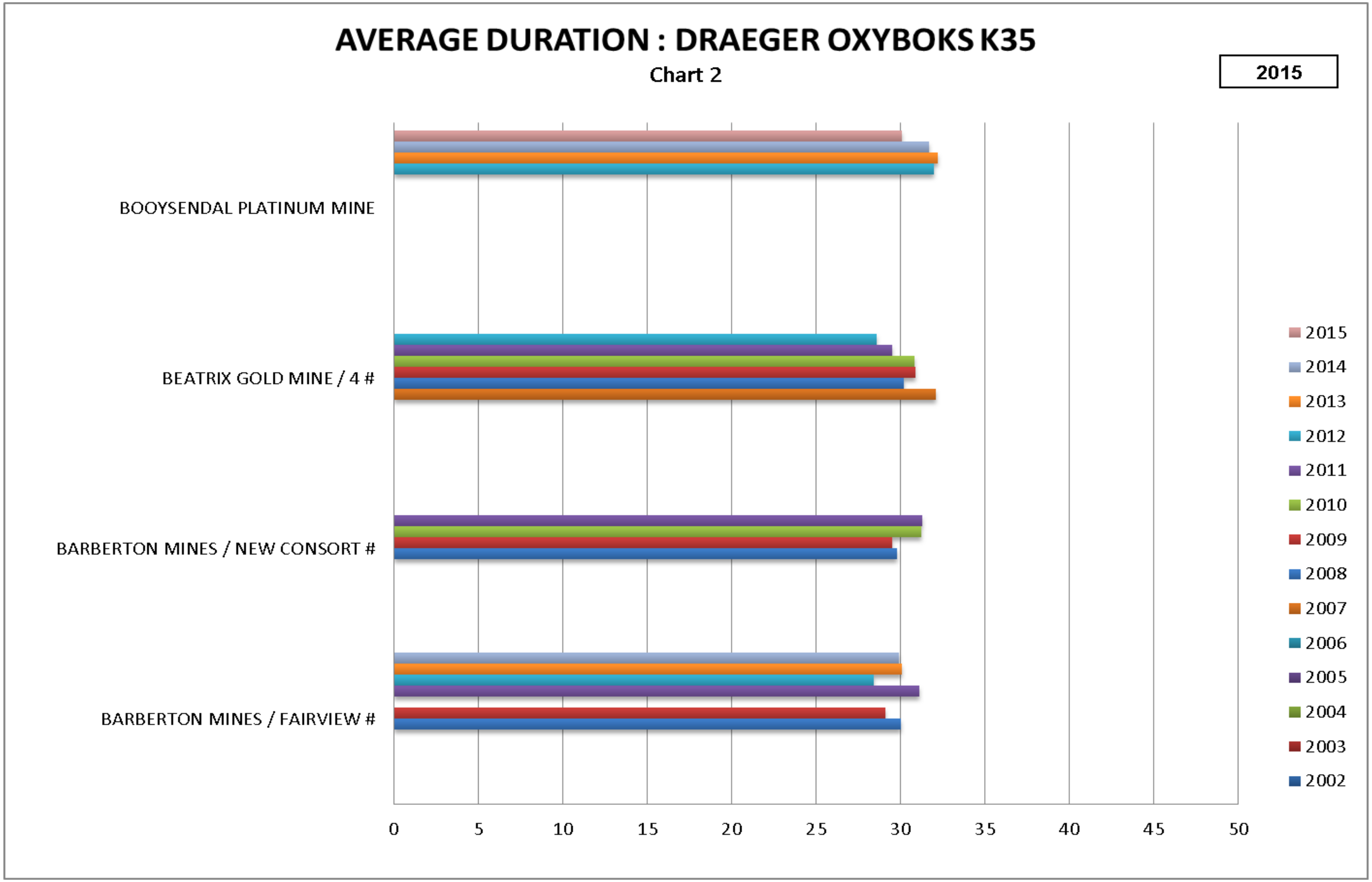
AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 2
2015
BOOYSENDAL PLATINUM MINE
BEATRIX GOLD MINE / 4 #
BARBERTON MINES / NEW CONSORT #
BARBERTON MINES / FAIRVIEW #
0
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2015
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2011
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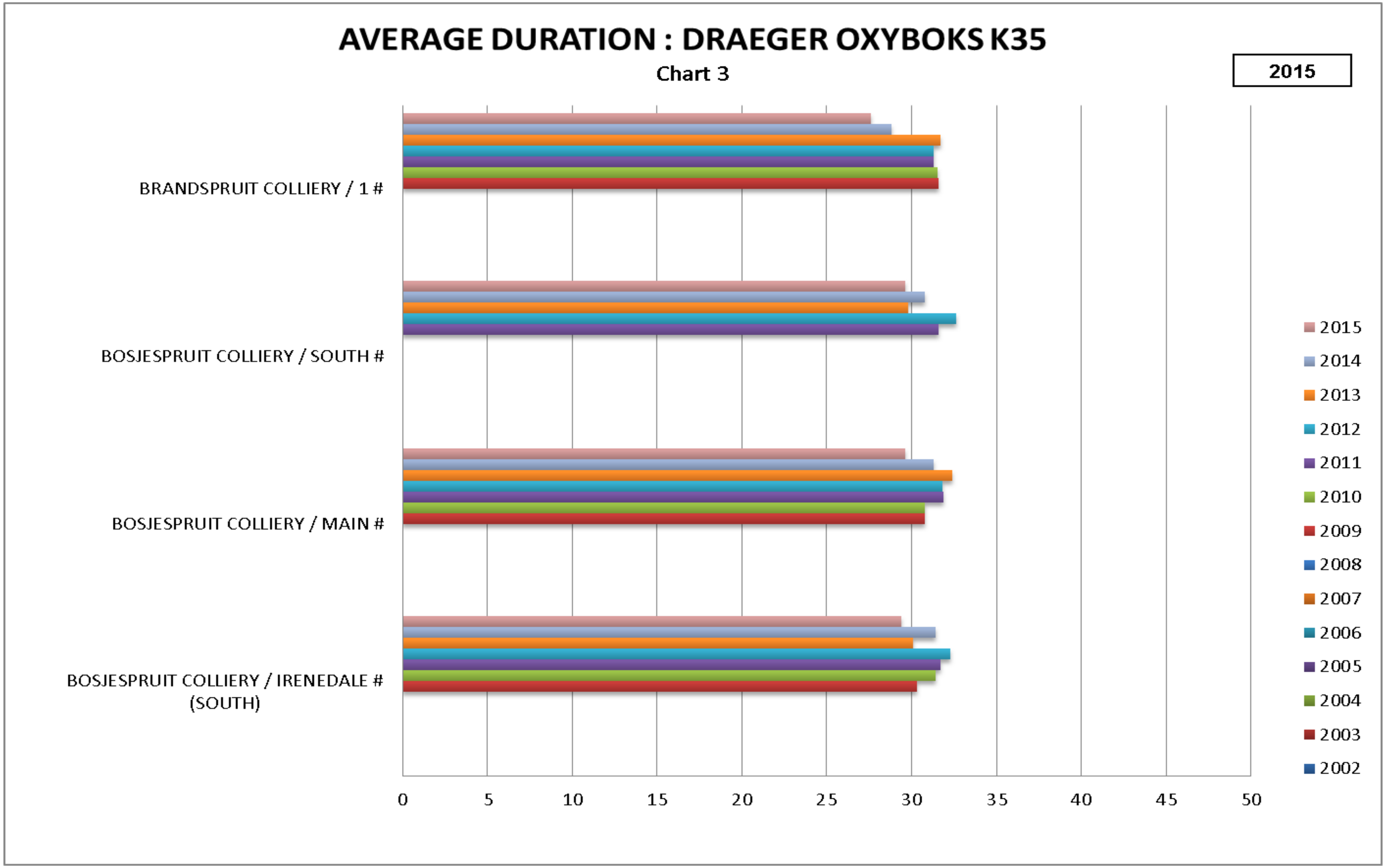

AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 3
2015
BRANDSPRUIT COLLIERY / 1 #
BOSJESPRUIT COLLIERY / SOUTH #
BOSJESPRUIT COLLIERY / MAIN #
BOSJESPRUIT COLLIERY / IRENEDALE # (SOUTH)
0
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2012
2011
2010
2009
2008
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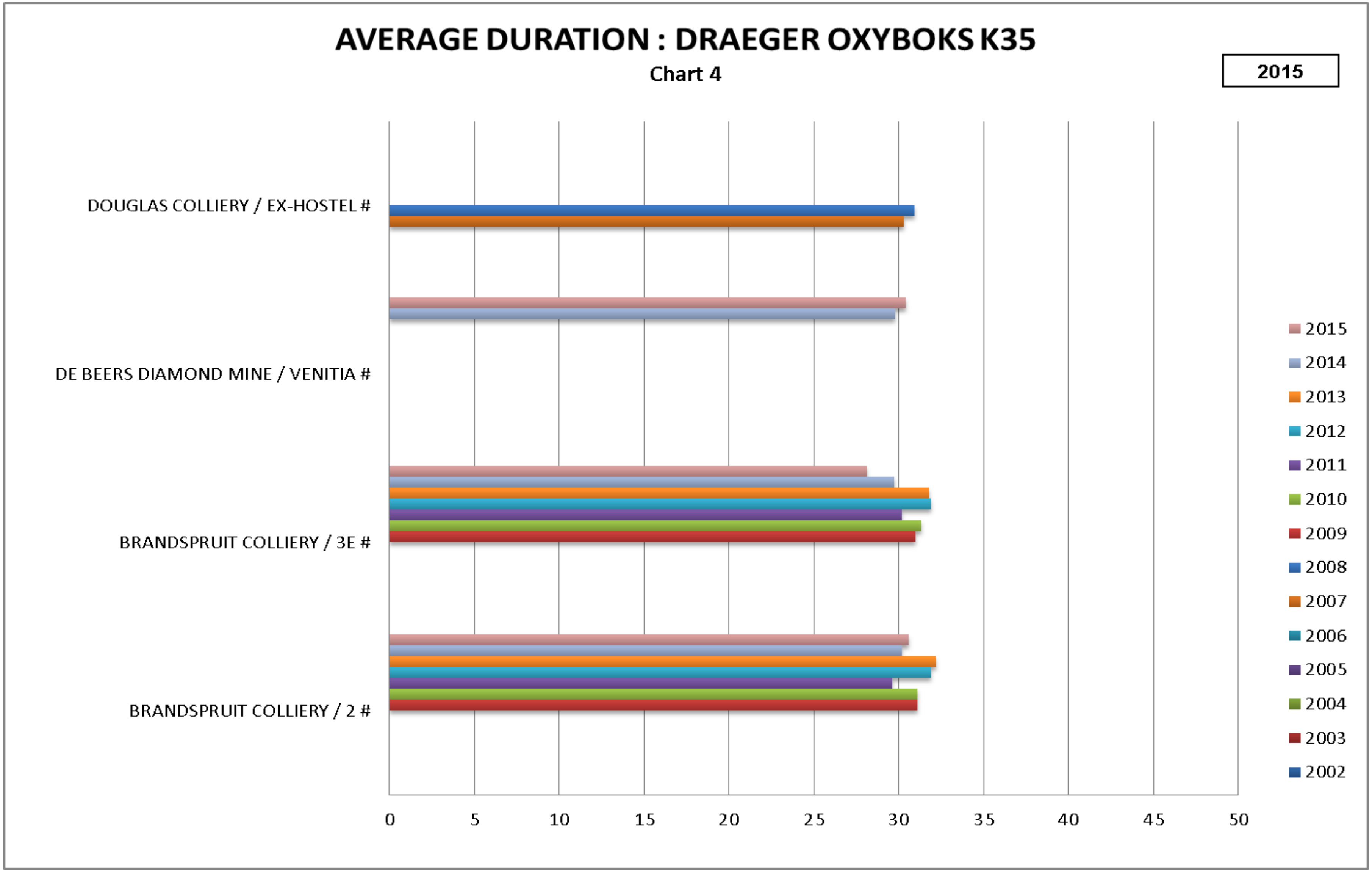

AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 4
2015
DOUGLAS COLLIERY / EX-HOSTEL #
DE BEERS DIAMOND MINE / VENITIA #
BRANDSPRUIT COLLIERY / 3E #
BRANDSPRUIT COLLIERY / 2 #
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2009
2008
2007
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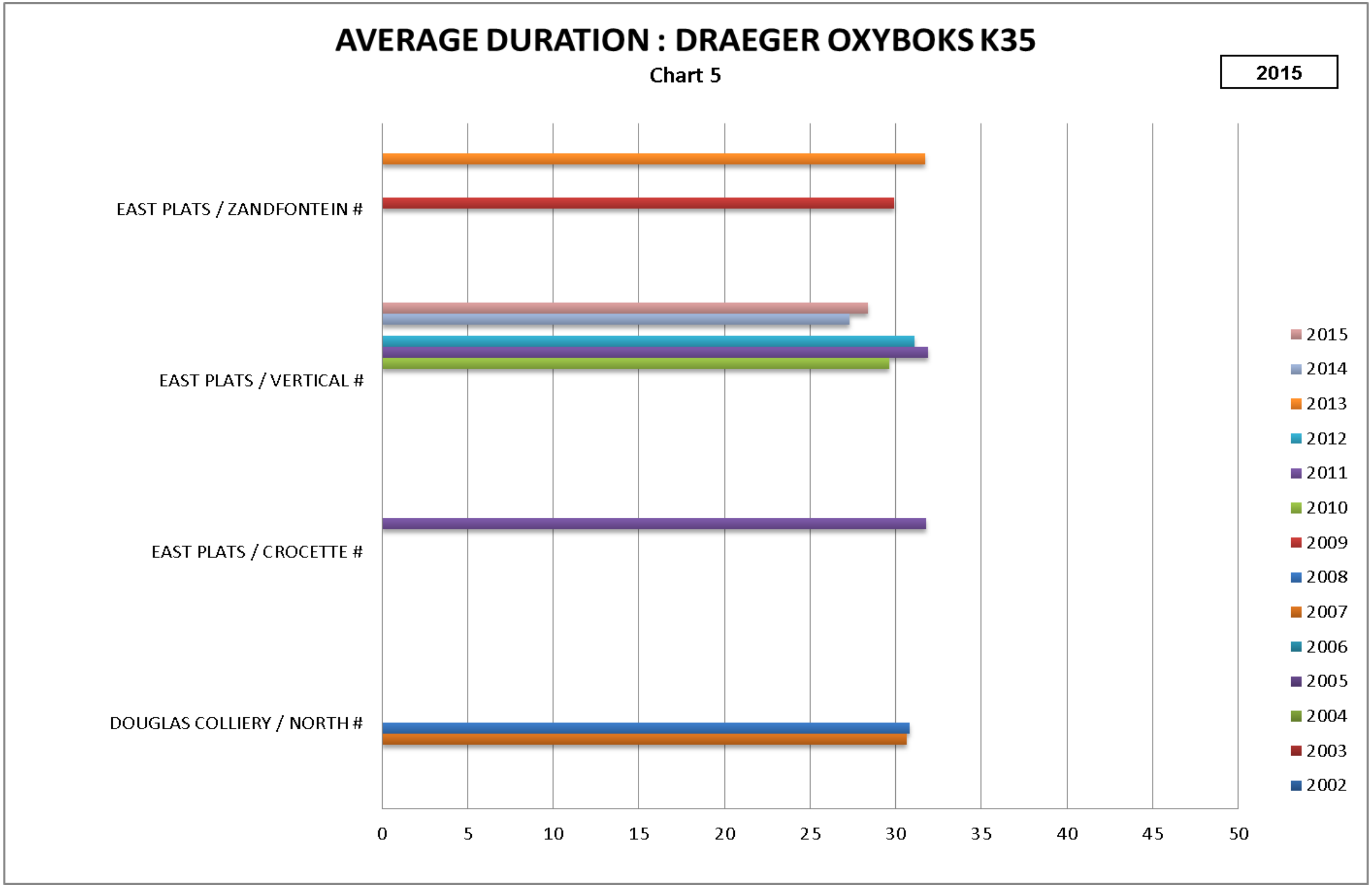
2004
2003
2002


AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 5
2015
EAST PLATS / ZANDFONTEIN #
EAST PLATS / VERTICAL #
EAST PLATS / CROCETTE #
DOUGLAS COLLIERY / NORTH #
0
5
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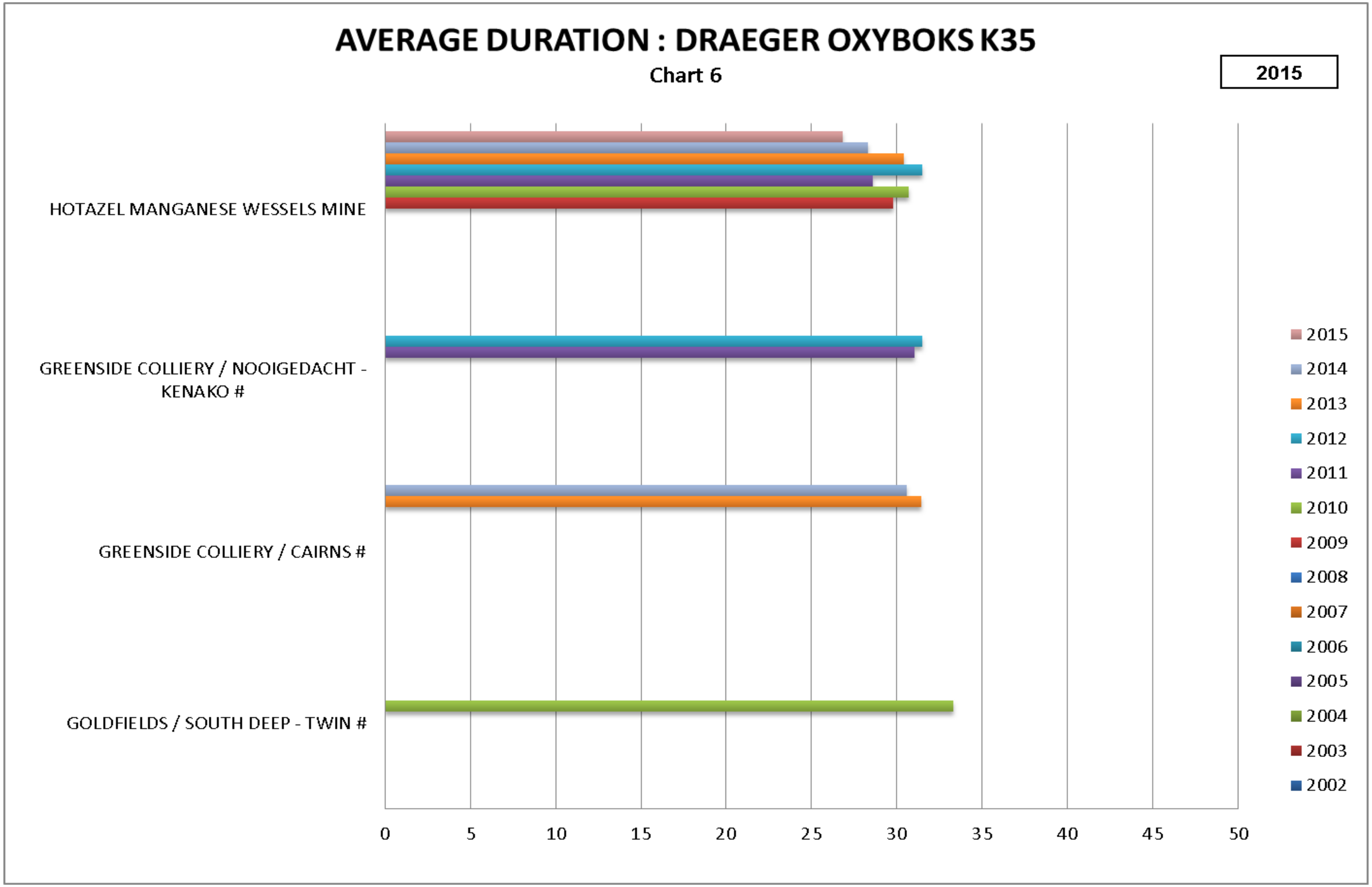
2002


AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 6
2015
HOTAZEL MANGANESE WESSELS MINE
GREENSIDE COLLIERY / NOOIGEDACHT - KENAKO #
GREENSIDE COLLIERY / CAIRNS #
GOLDFIELDS / SOUTH DEEP - TWIN #
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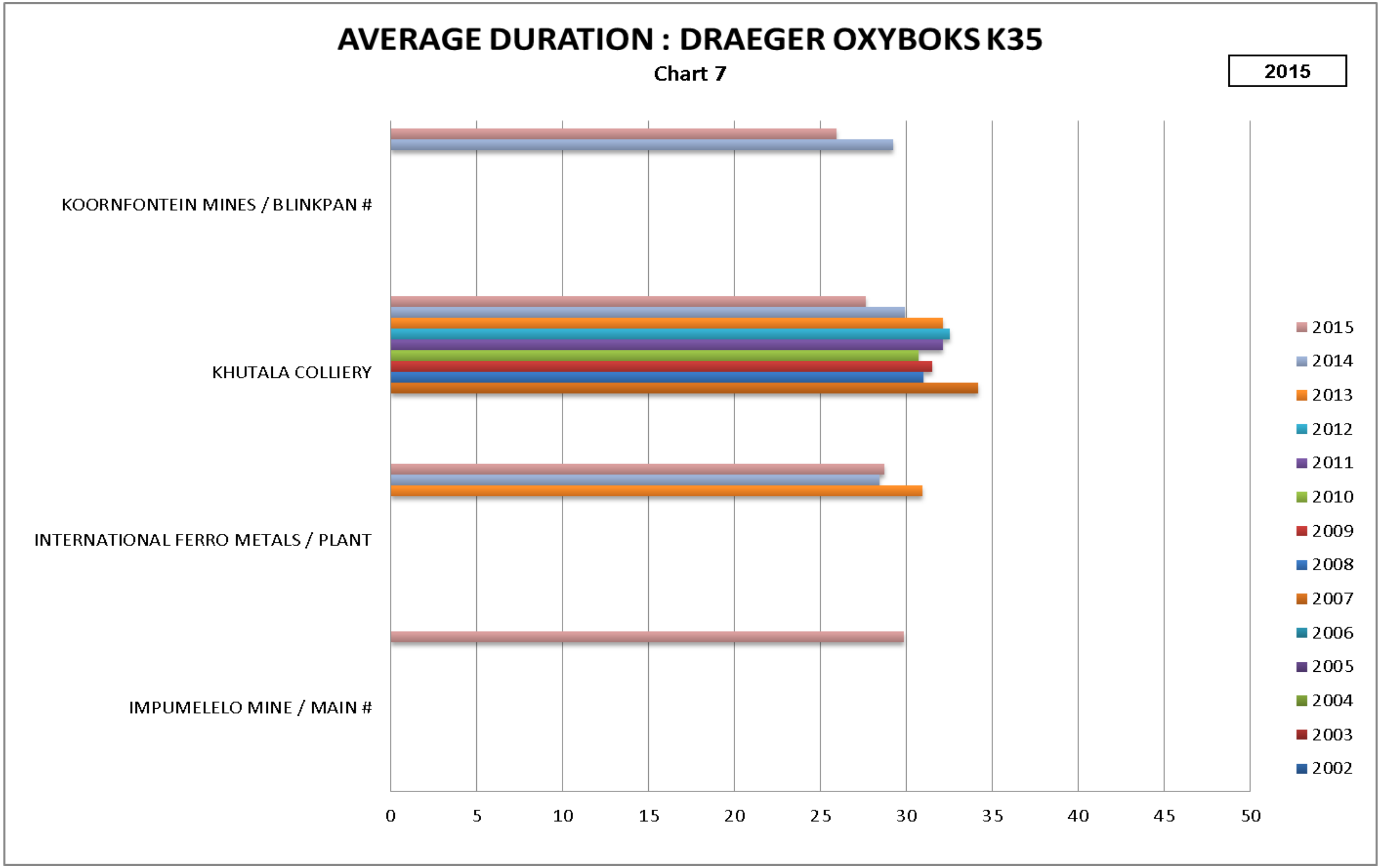
AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 7
2015
KOORNFONTEIN MINES / BLINKPAN #
KHUTALA COLLIERY
INTERNATIONAL FERRO METALS / PLANT
IMPUMELELO MINE / MAIN #
0
5
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2009
2008
2007
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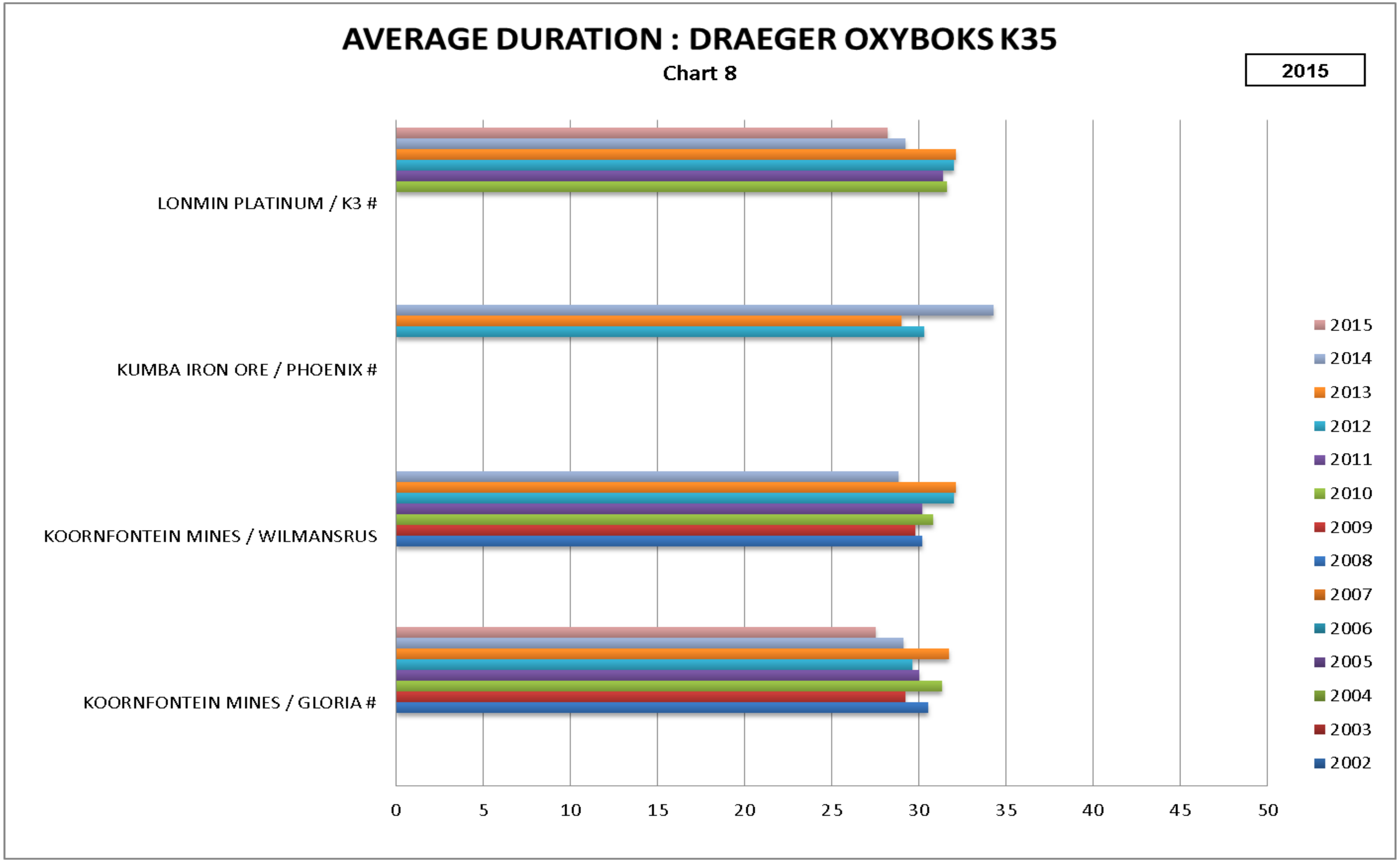
2002


AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 8
2015
LONMIN PLATINUM / K3 #
KUMBA IRON ORE / PHOENIX #
KOORNFONTEIN MINES / WILMANSRUS
KOORNFONTEIN MINES / GLORIA #
0
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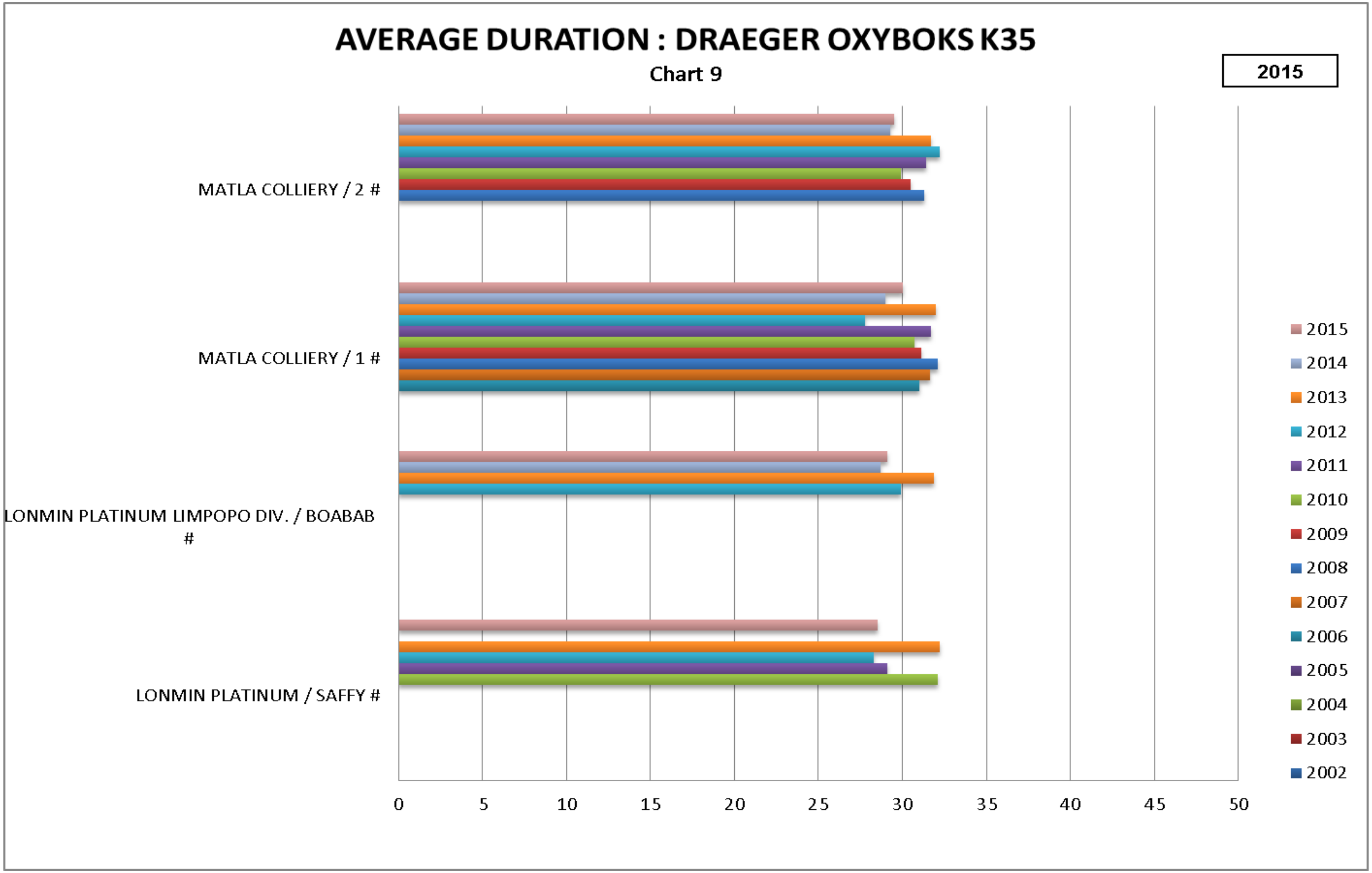
AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 9
2015
MATLA COLLIERY / 2 #
MATLA COLLIERY / 1 #
LONMIN PLATINUM LIMPOPO DIV. / BOABAB #
LONMIN PLATINUM / SAFFY #
0
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2011
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2009
2008
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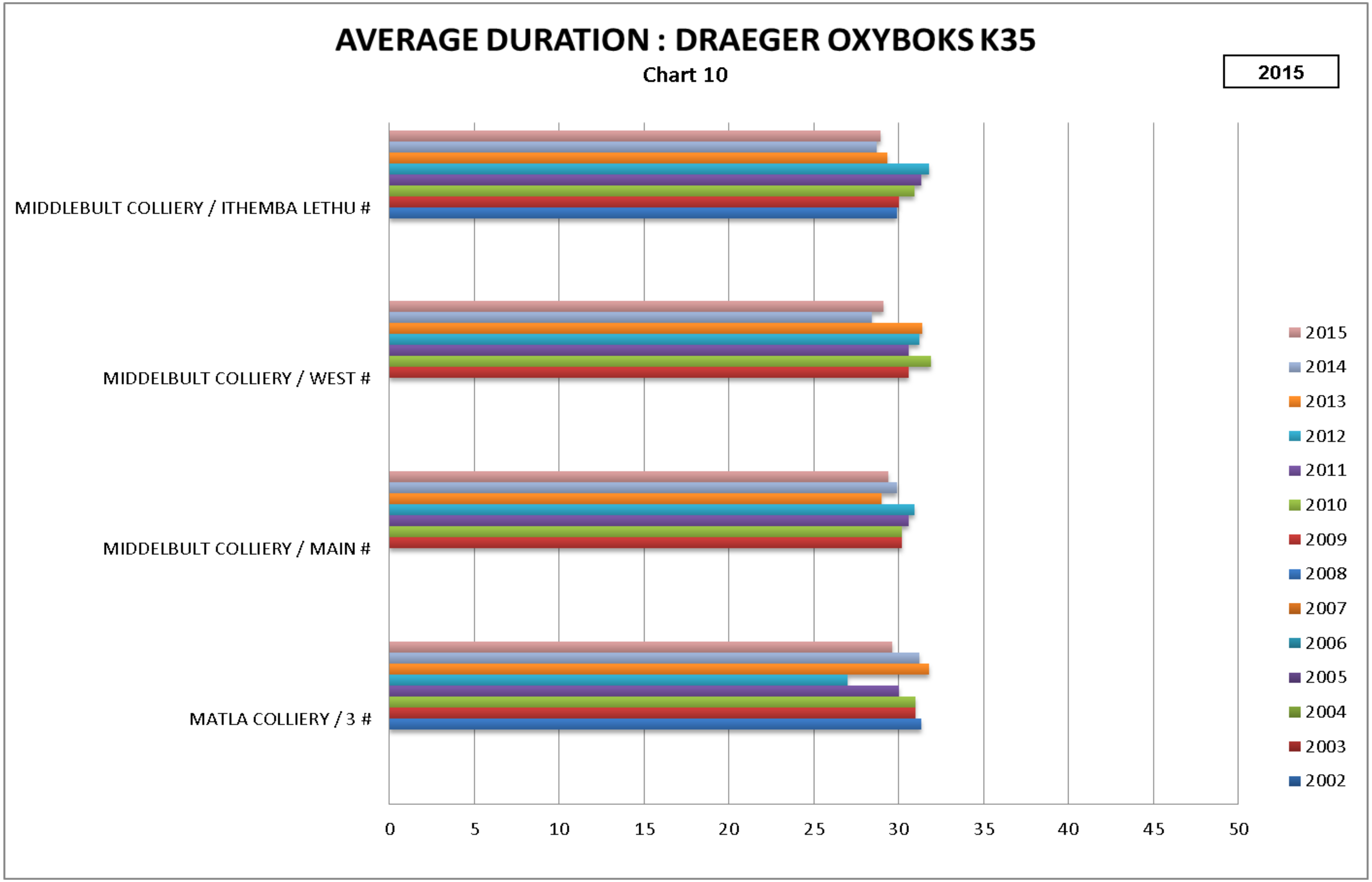
2002



AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 10
2015
MIDDLEBULT COLLIERY / ITHEMBA LETHU #
MIDDELBULT COLLIERY / WEST #
MIDDELBULT COLLIERY / MAIN #
MATLA COLLIERY / 3 #
0
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2015
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2013
2012
2011
2010
2009
2008
2007
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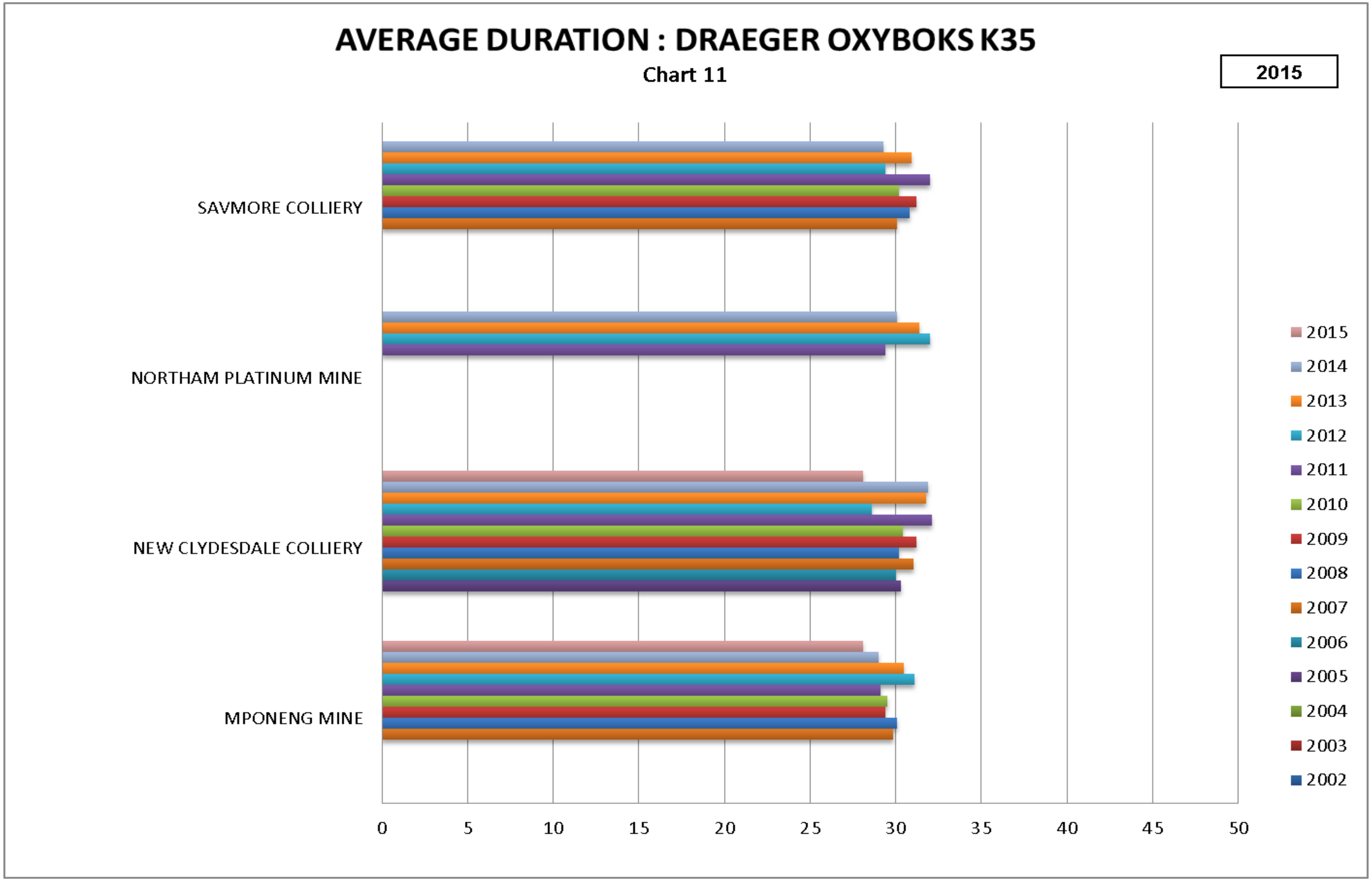
AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 11
2015
SAVMORE COLLIERY
NORTHAM PLATINUM MINE
NEW CLYDESDALE COLLIERY
MPONENG MINE
0
5
10
15
20
25
30
35
40
45
50
2015
2014
2013
2012
2011
2010
2009
2008
2007
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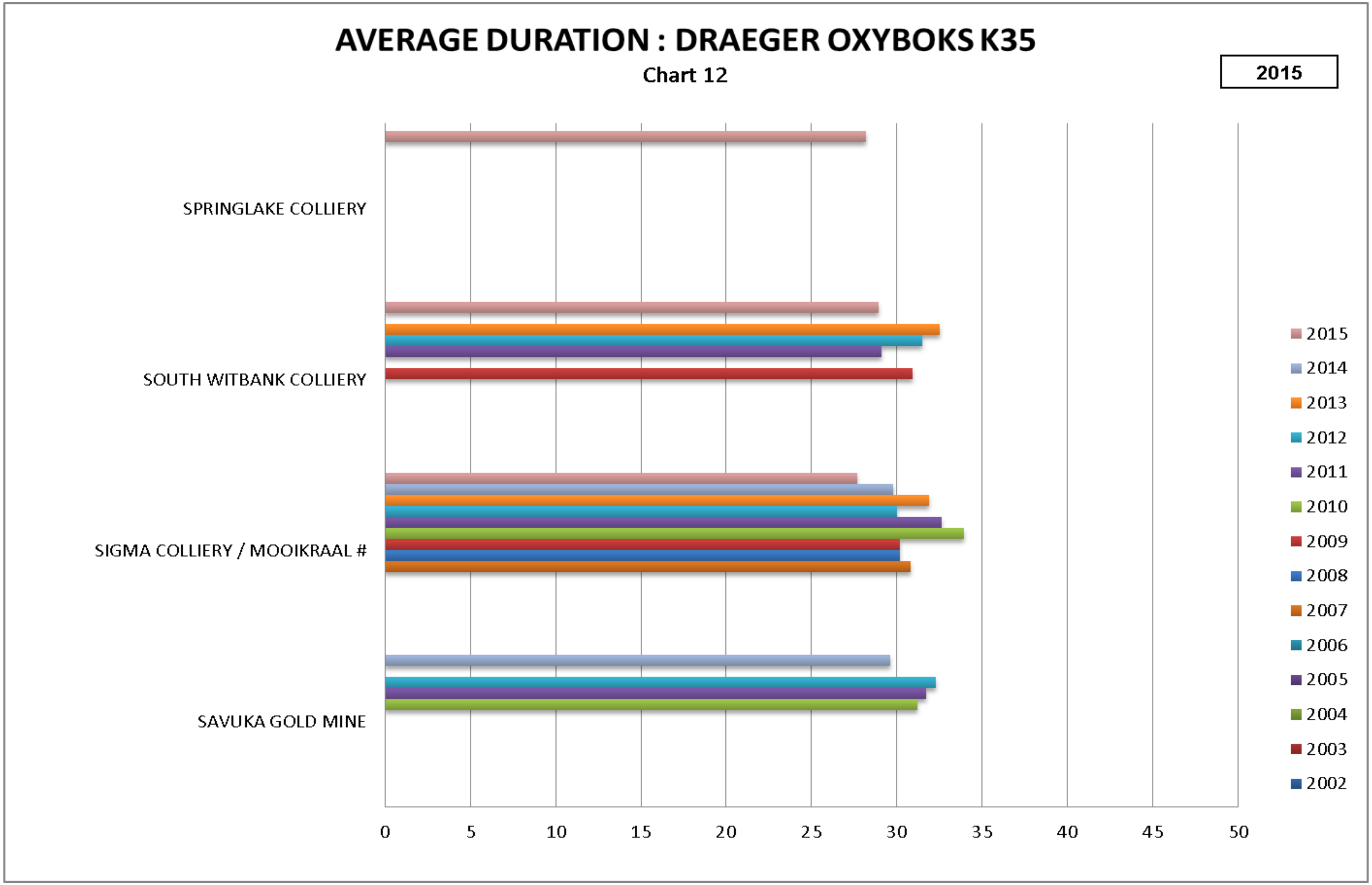
2002


AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 12
2015
SPRINGLAKE COLLIERY
SOUTH WITBANK COLLIERY
SIGMA COLLIERY / MOOIKRAAL #
SAVUKA GOLD MINE
0
5
10
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25
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45
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2015
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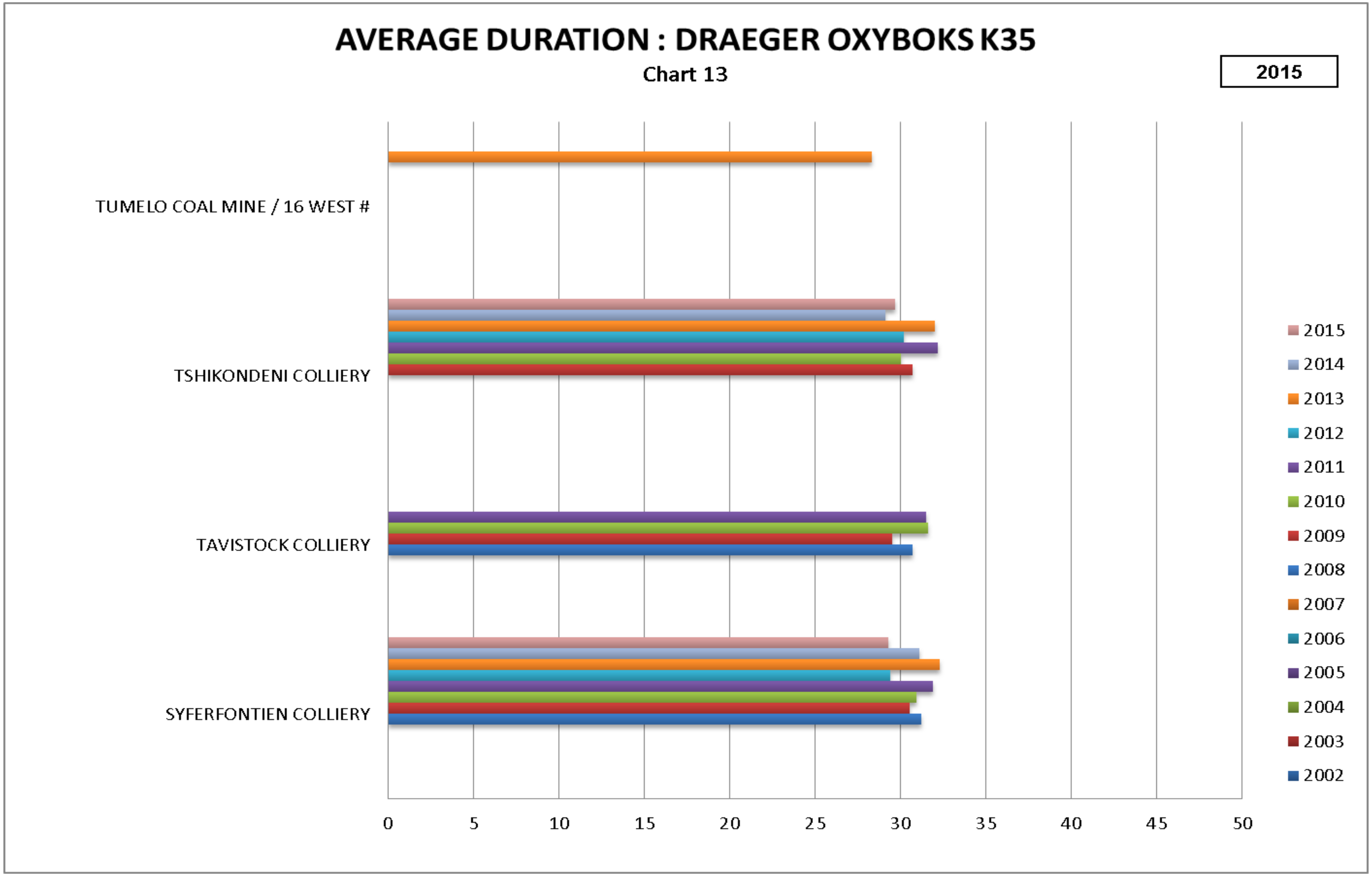

AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 13
2015
TUMELO COAL MINE / 16 WEST #
TSHIKONDENI COLLIERY
TAVISTOCK COLLIERY
SYFERFONTIEN COLLIERY
0
5
10
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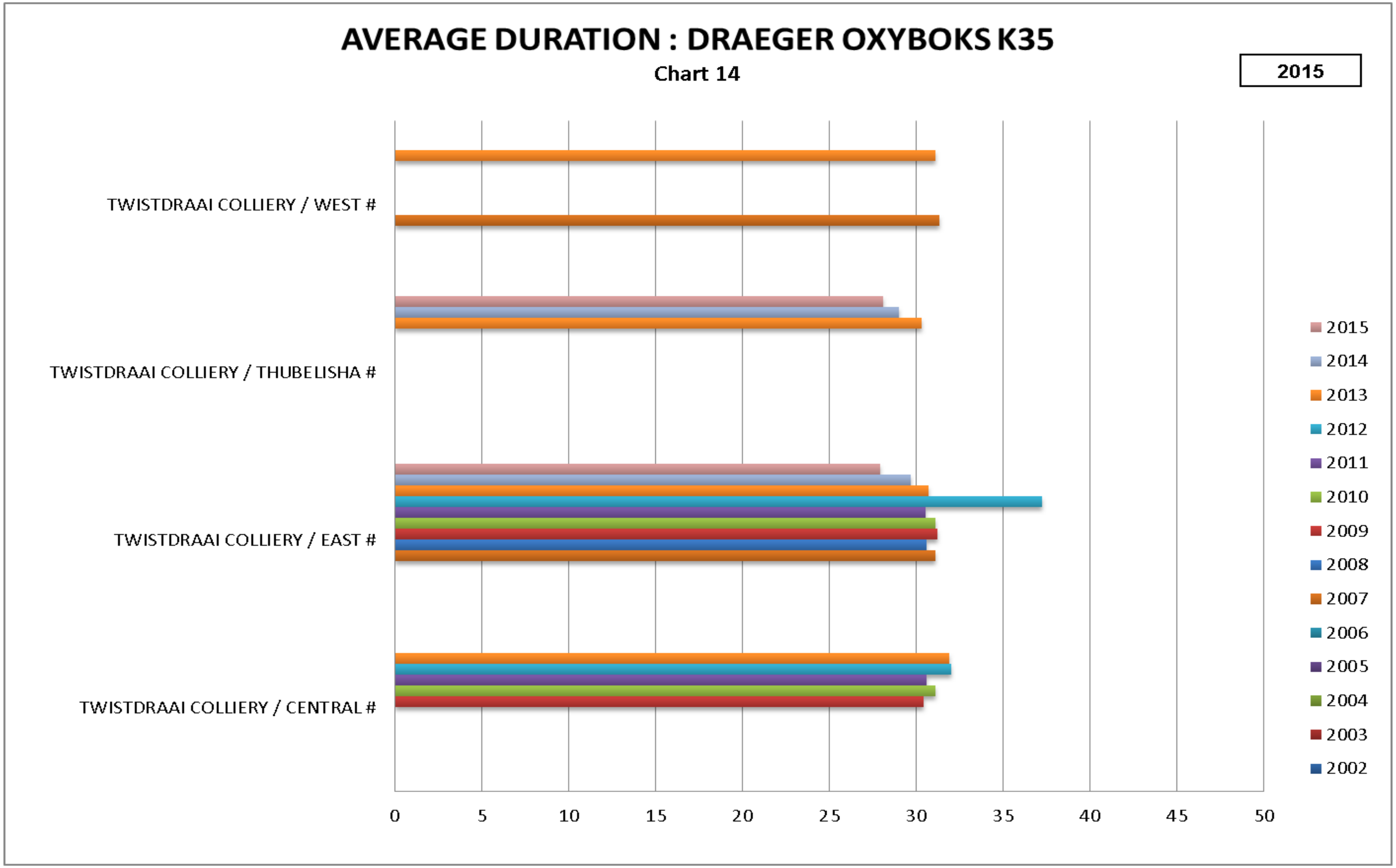

AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 14
2015
TWISTDRAAI COLLIERY / WEST #
TWISTDRAAI COLLIERY / THUBELISHA #
TWISTDRAAI COLLIERY / EAST #
TWISTDRAAI COLLIERY / CENTRAL #
0
5
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2015
2014
2013
2012
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2009
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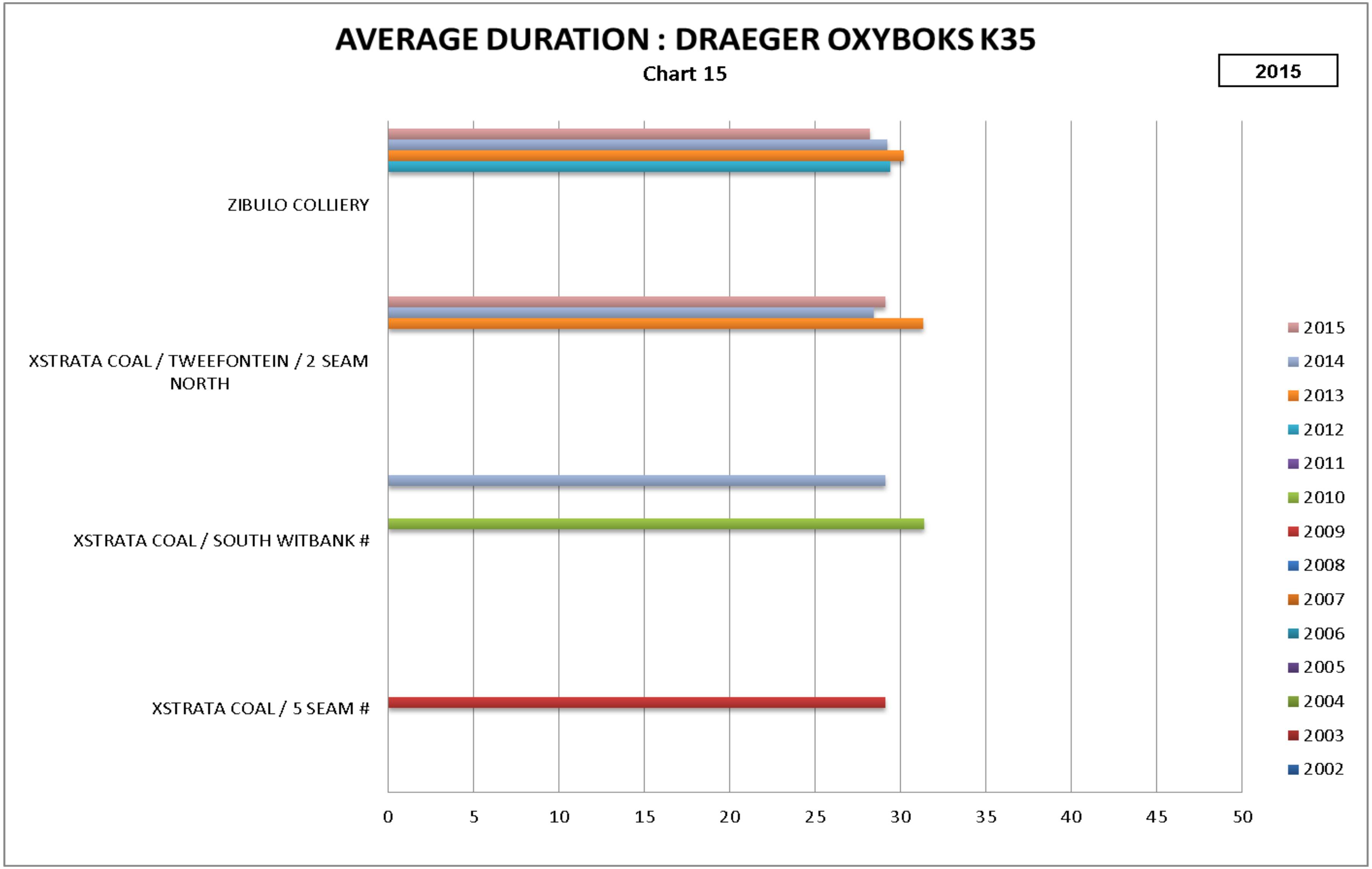
AVERAGE DURATION : DRAEGER OXYBOKS K35
Chart 15
2015
ZIBULO COLLIERY
XSTRATA COAL / TWEEFONTEIN / 2 SEAM NORTH
XSTRATA COAL / SOUTH WITBANK #
XSTRATA COAL / 5 SEAM #
0
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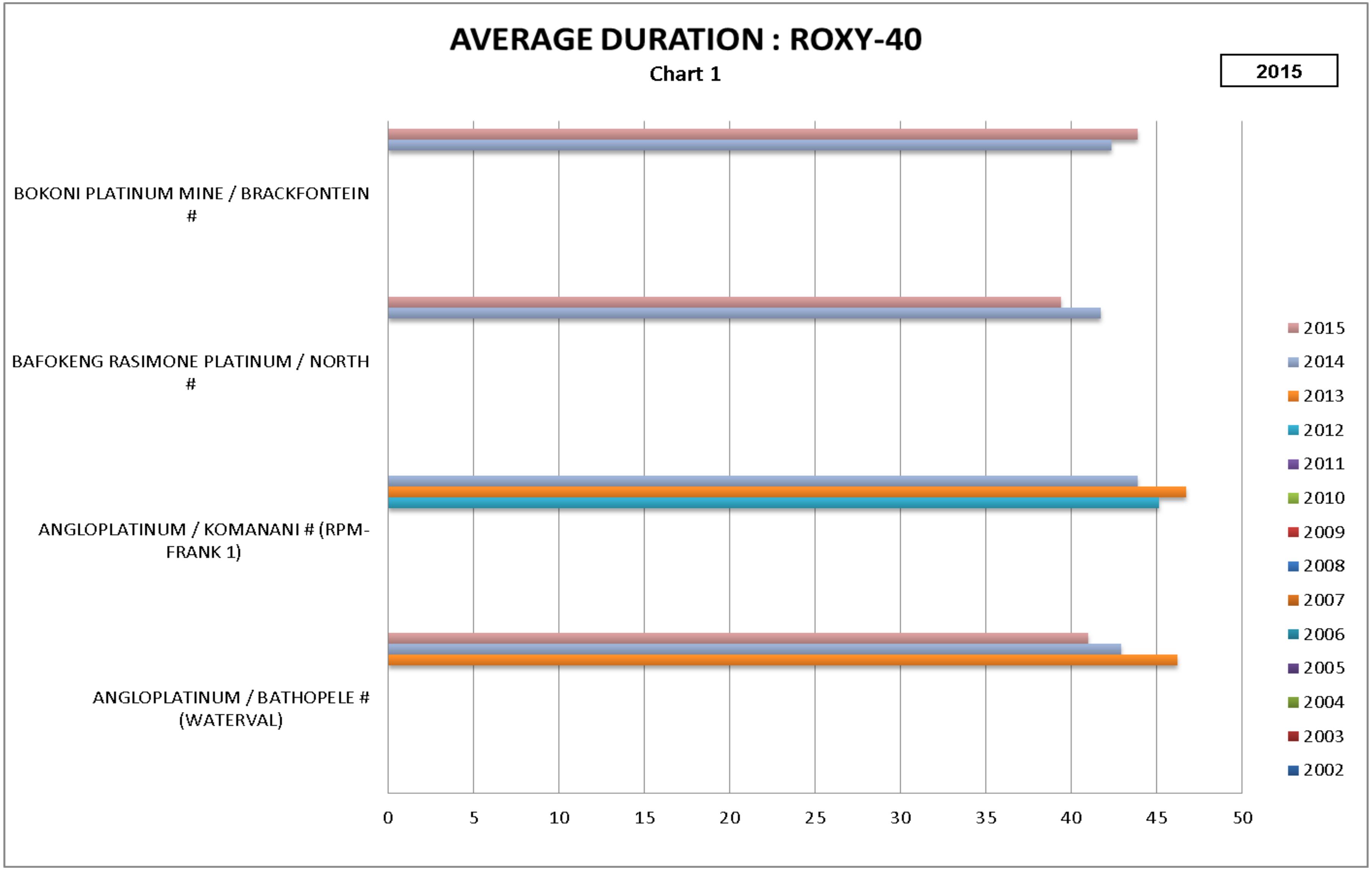
AVERAGE DURATION : ROXY-40
Chart 1
2015
BOKONI PLATINUM MINE / BRACKFONTEIN #
BAFOKENG RASIMONE PLATINUM / NORTH #
ANGLOPLATINUM / KOMANANI # (RPM-FRANK 1)
ANGLOPLATINUM / BATHOPELE # (WATERVAL)
0
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50
2015
2014
2013
2012
2011
2010
2009
2008
2007
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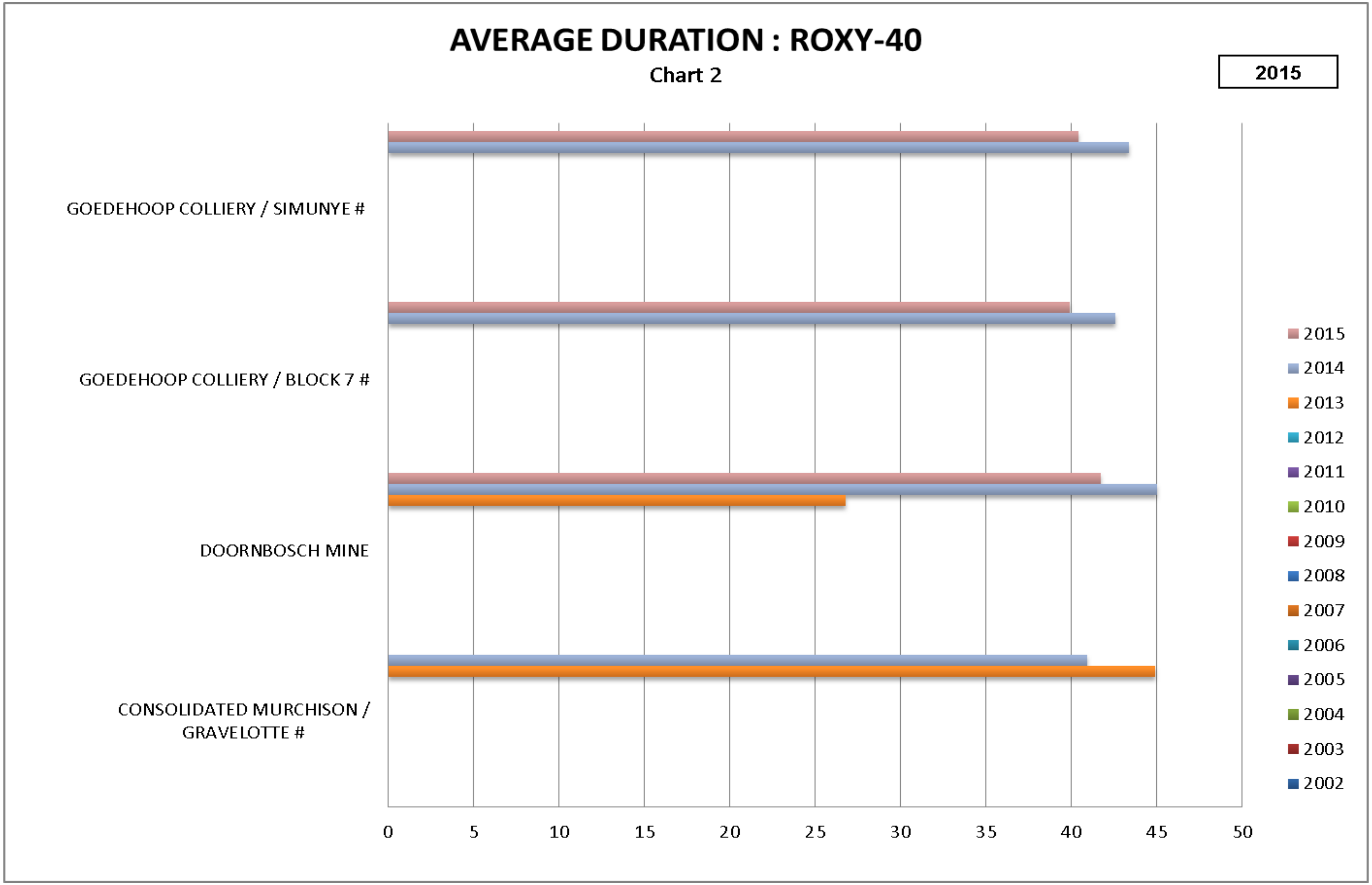
AVERAGE DURATION : ROXY-40
Chart 2
2015
GOEDEHOOP COLLIERY / SIMUNYE #
GOEDEHOOP COLLIERY / BLOCK 7 #
DOORNBOSCH MINE
CONSOLIDATED MURCHISON / GRAVELOTTE #
0
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2009
2008
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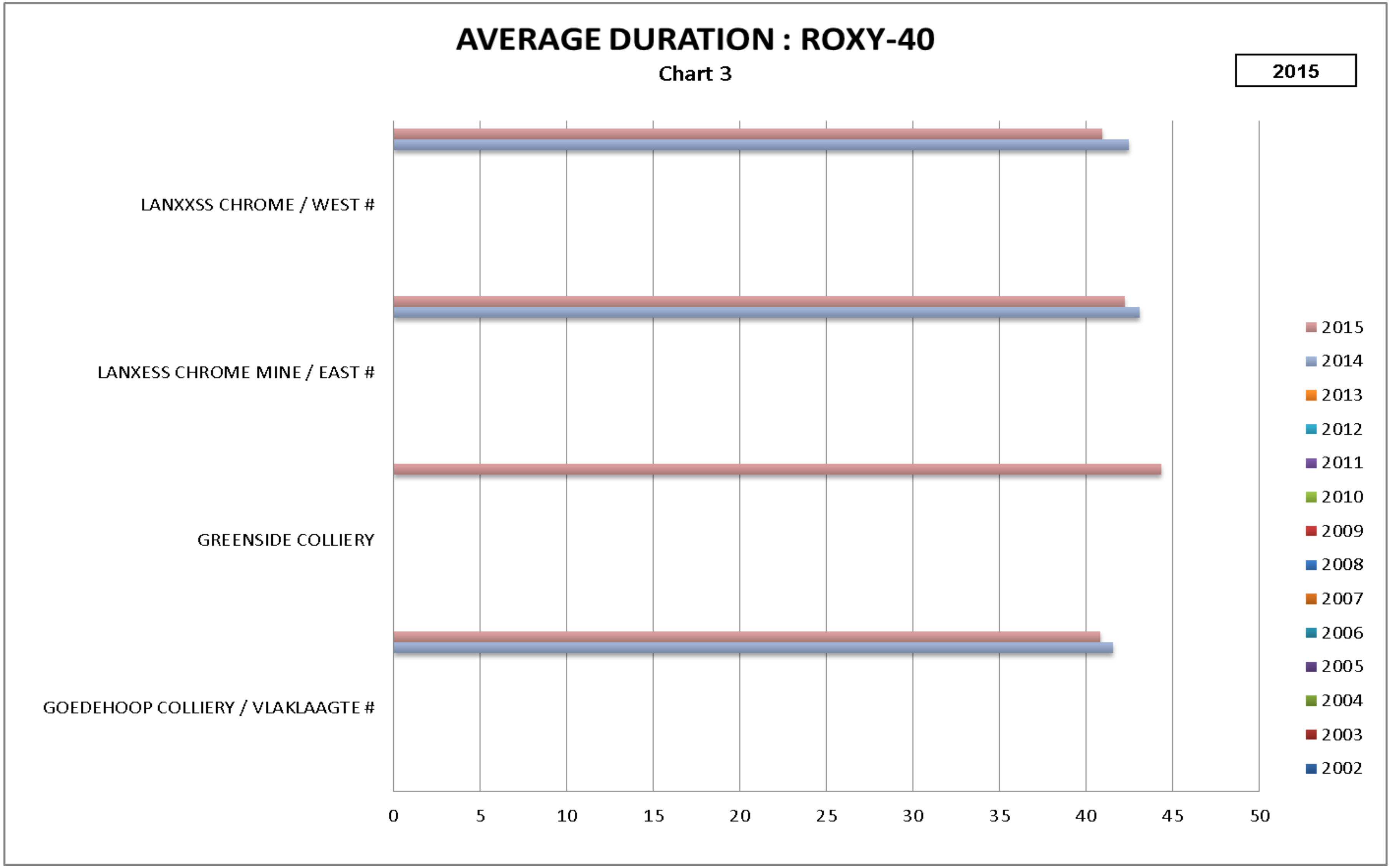

AVERAGE DURATION : ROXY-40
Chart 3
2015
LANXXSS CHROME / WEST #
LANXESS CHROME MINE / EAST #
GREENSIDE COLLIERY
GOEDEHOOP COLLIERY / VLAKLAAGTE #
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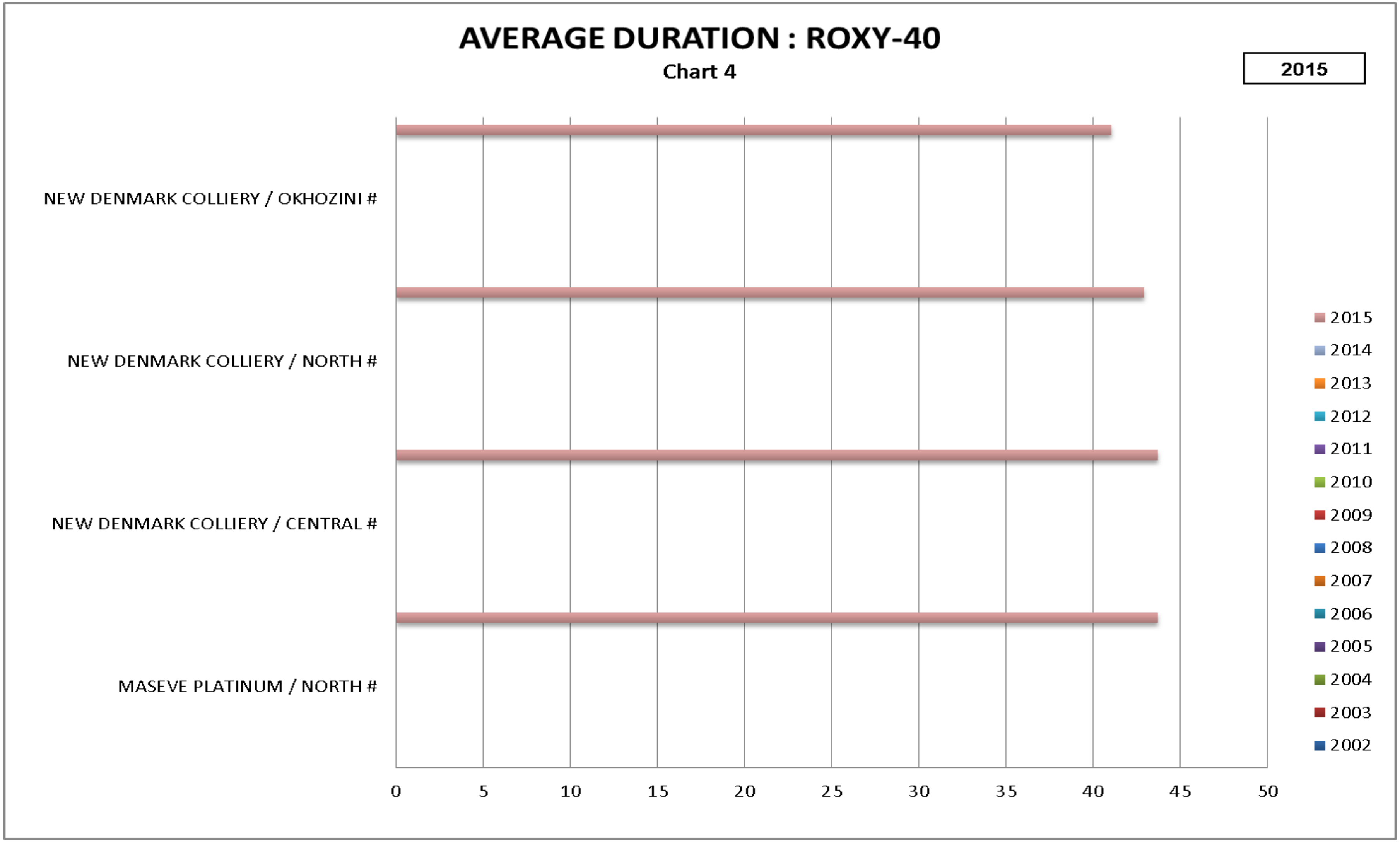
AVERAGE DURATION : ROXY-40
Chart 4
2015
NEW DENMARK COLLIERY / OKHOZINI #
NEW DENMARK COLLIERY / NORTH #
NEW DENMARK COLLIERY / CENTRAL #
MASEVE PLATINUM / NORTH #
0
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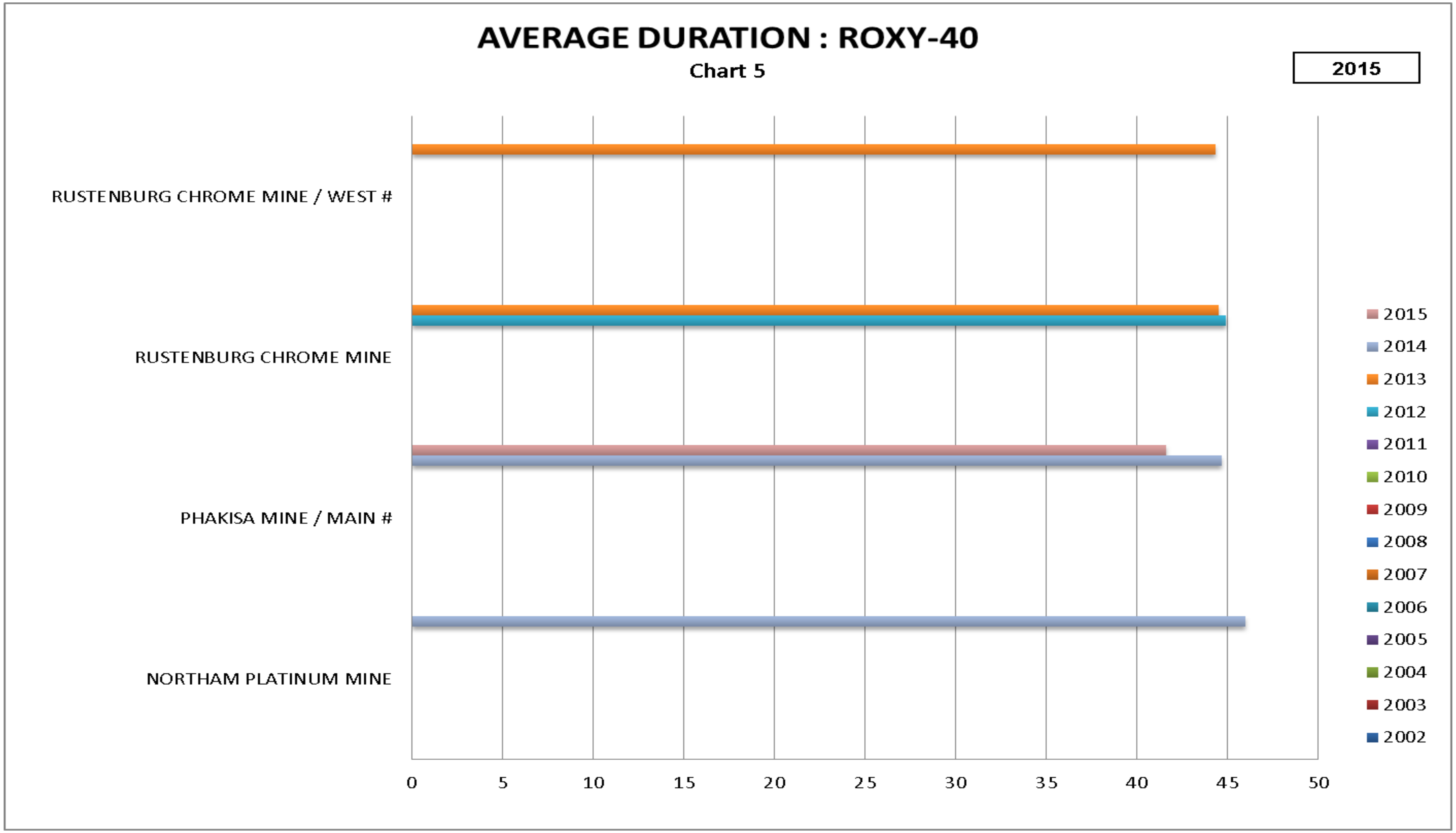
AVERAGE DURATION : ROXY-40
Chart 5
2015
RUSTENBURG CHROME MINE / WEST #
RUSTENBURG CHROME MINE
PHAKISA MINE / MAIN #
NORTHAM PLATINUM MINE
0
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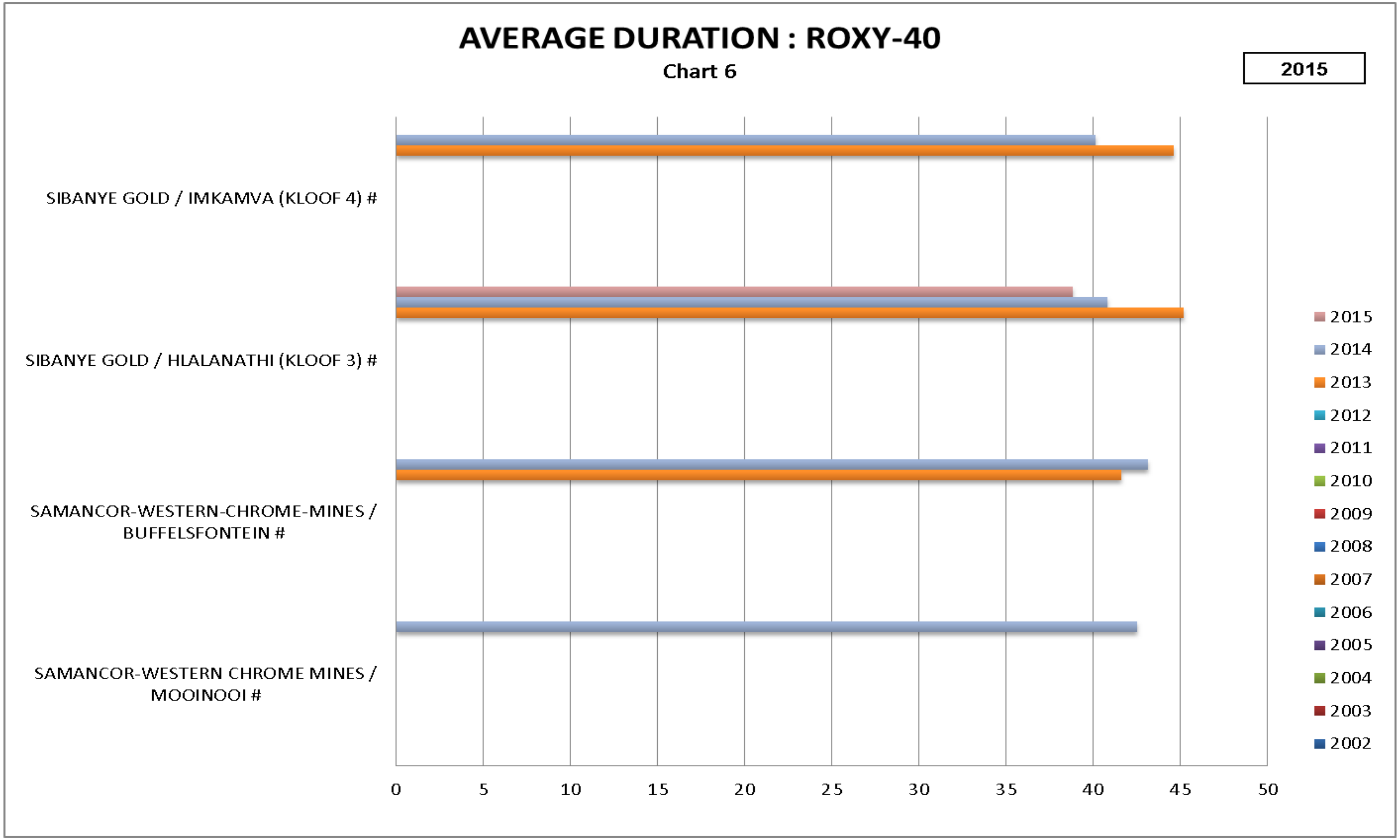
AVERAGE DURATION : ROXY-40
Chart 6
2015
SIBANYE GOLD / IMKAMVA (KLOOF 4) #
SIBANYE GOLD / HLALANATHI (KLOOF 3) #
SAMANCOR-WESTERN-CHROME-MINES / BUFFELSFONTEIN #
SAMANCOR-WESTERN CHROME MINES / MOOINOOI #
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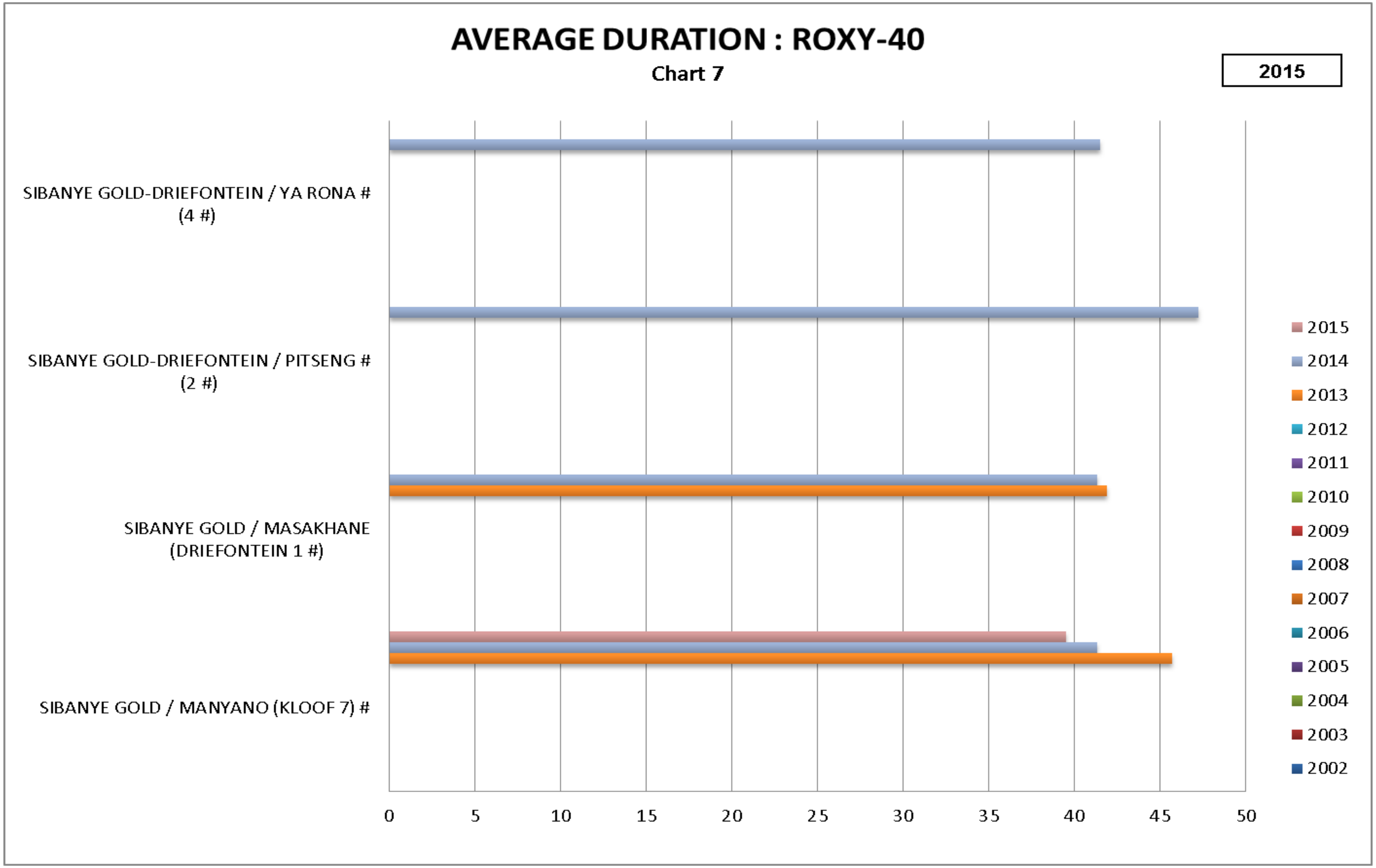

AVERAGE DURATION : ROXY-40
Chart 7
2015
SIBANYE GOLD-DRIEFONTEIN / YA RONA # (4 #)
SIBANYE GOLD-DRIEFONTEIN / PITSENG # (2 #)
SIBANYE GOLD / MASAKHANE (DRIEFONTEIN 1 #)
SIBANYE GOLD / MANYANO (KLOOF 7) #
0
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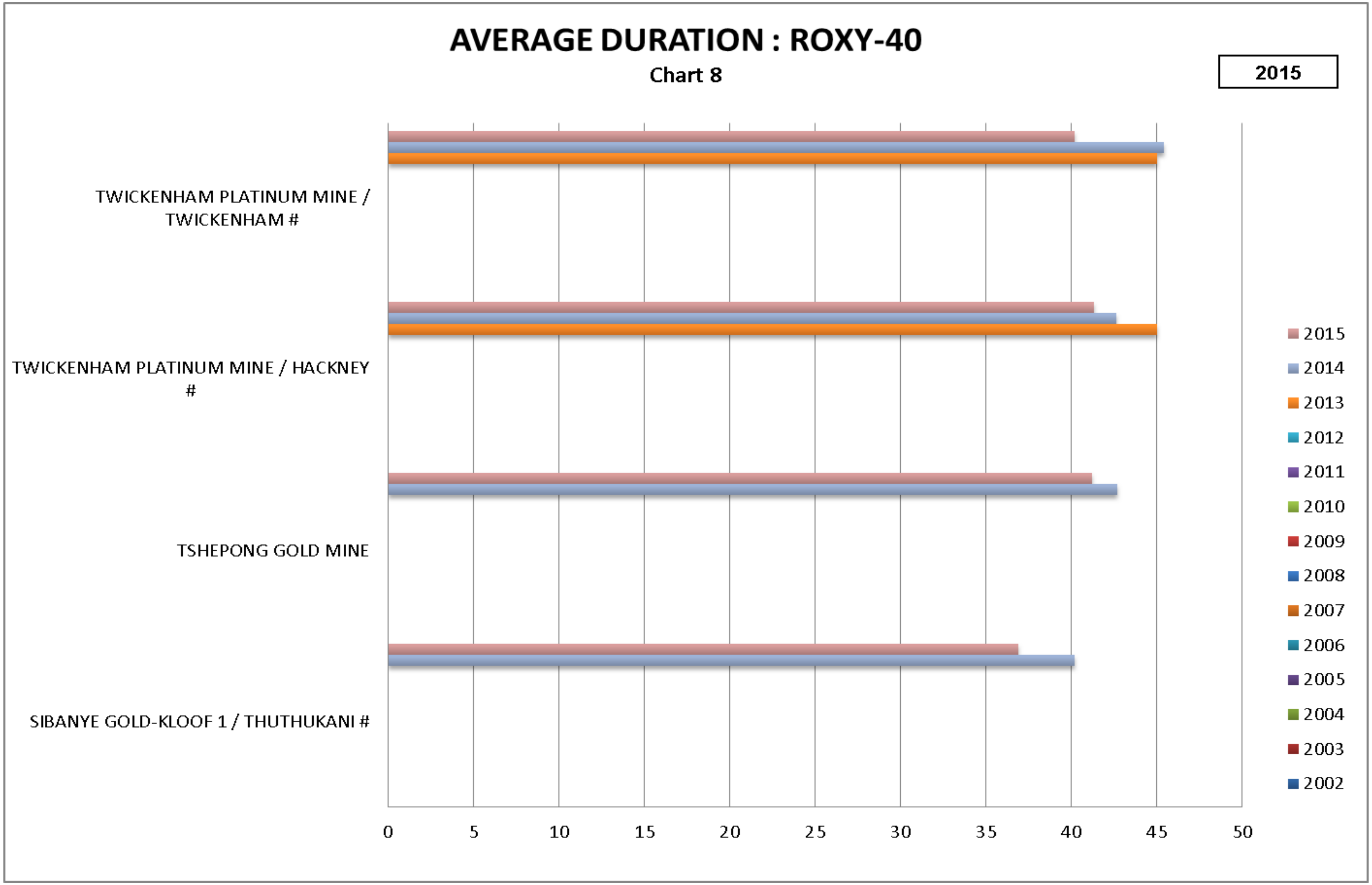
AVERAGE DURATION : ROXY-40
Chart 8
2015
TWICKENHAM PLATINUM MINE / TWICKENHAM #
TWICKENHAM PLATINUM MINE / HACKNEY #
TSHEPONG GOLD MINE
SIBANYE GOLD-KLOOF 1 / THUTHUKANI #
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Appendix 2
Definition of functional performance categories of SCSRs

Category 1

Functional performance falls outside approval specification but with life-saving potential unimpaired.

Category 2

- Functional performance exceeds rejection limits,
- Safe functional performance duration reduced by 50 % or more,
- Major material or structural faults, which would jeopardize survival if the SCSR were used in an escape mode.

The relevant approval levels for new units, and rejection levels for units which are deployed in the South African mining industry, are provided in the following table. In the absence of specific levels formulated to represent acceptable levels of functional performance (i.e. to accommodate the degeneration associated with daily deployment underground), the region between approval and rejection levels is deemed to satisfy the category 1 requirements.

Parameter	Approval Specification SABS 839 (CKM)	Approval Specification SANS 1737	Rejection Level
Inhalation oxygen concentration (minimum % by volume)	*21	*21	*21
Inhalation carbon dioxide concentration (maximum % by volume)	2,5	3,0	5
Inhalation air temperature maximum dry bulb (degrees centigrade)	85	75	85
Inhalation breathing resistance (Pascal)	600	800	1500
Exhalation breathing resistance (Pascal)	600	800	1500

* A short-term deviation to a level of not less than 17 % by volume and for a period of not more than 2 minutes at the beginning of the test is permissible.

Appendix 3

Regulation/Chapter 16.2, 16.3 and 16.4

Self-Contained Self-Rescuers

16.2 Issuing of Self-Contained Self-Rescuers

Coal Mines

16.2(1) The employer of every coal mine must ensure that no person goes underground at the mine without a body-worn self-contained self-rescuer, which complies with the South African Bureau of Standards specification SANS 1737.

Mines other than Coal Mines

16.2(2) If at any mine other than a coal mine the risk assessment in terms of Section 11 shows that there is a significant risk that employee's may be exposed to irrespirable atmospheres at any area at the mine, the employer must ensure that no person goes into such area without a body worn self-contained self-rescuer, which complies with the South African Bureau of Standards specification SANS 1737.

Sole Allocation of a Self-Contained Self-Rescuer

16.2(3) Anybody worn self-contained self-rescuer supplied to any employee employed in a full time capacity at the mine, in terms of sub regulations 16.2(1) and 16.2, must be allocated to the employee for that employee's sole use for the duration of the deployment of that self-contained self-rescuer at the mine or until that self-contained self-rescuer becomes defective and the employee is issued with another self-contained self-rescuer as required by these regulations.

16.3 No Defective Self-Contained Self-Rescuer is issued

Employer to ensure no defective self-contained self-rescuer is issued

16.3(1) The employer must ensure that no defective self-contained self-rescuer is issued for use to any employee at a mine.

16.4 Monitoring Programme

Annual testing of a Self-Contained Self-Rescuer

16.4(1) The employer must annually have a representative sample of self-contained self-rescuers at the mine tested by an organization accredited to do so in terms of the South African National Accreditation system for assessment of the structural integrity and functional performance.

Such representative sample must not be less than 1 % of the self-contained self-rescuers at the mine and must be representative of the age and deployment of the self-contained self-rescuers.

16.4(2) The employer must keep the following information, on self-contained self-rescuers at the mine, covering the preceding 24 months: -

a) total number and makes of self-contained self-rescuers in service at the mine;
b) number and make of self-contained self-rescuers purchased by the mine in that period;
c) number and make of self-contained self-rescuers withdrawn from use by the mine in that period;
d) the number of shifts worked per day (1, 2 or 3);
e) number of self-contained self-rescuers in daily use (average for each month);
f) number of employees underground (average per shift);
g) number of spare self-contained self-rescuers available (average per month);
h) a tabulation of the type of defects found;
i) number of self-contained self-rescuers repaired/refurbished; and
j) number of self-contained self-rescuers tested in terms of regulation 16.4(1)